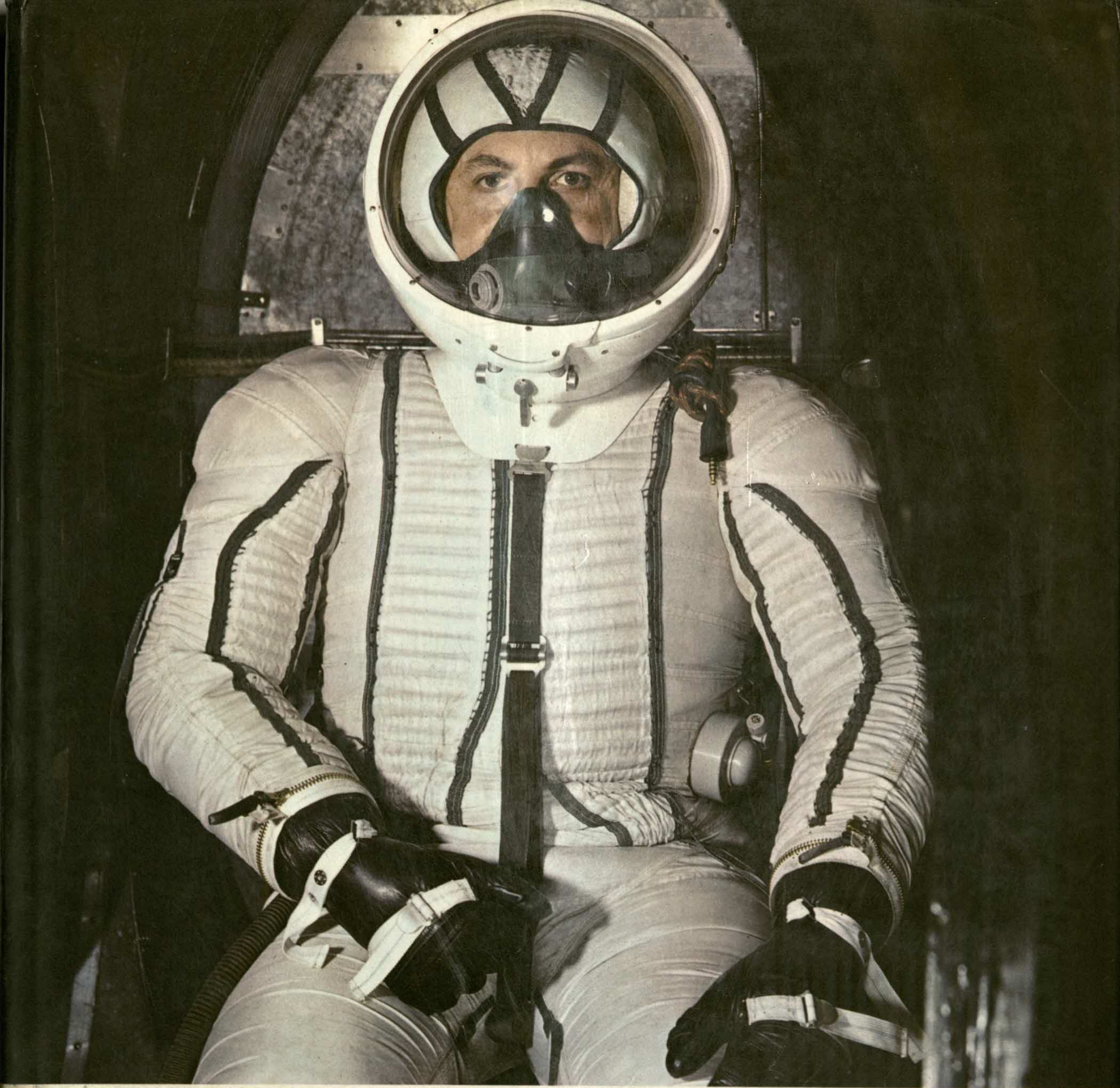


KISTER

THE LIVING UNIVERSE
An Encyclopaedia of
the Biological Sciences

Man of tomorrow

Man of tomorrow

A/10/2

STATE INSTITUTE OF EDUCATION

S.C.E.R.T., West Bengal
Library
Calcutta
25/3, B. C. Road

THE LIVING UNIVERSE : AN ENCYCLOPAEDIA OF THE BIOLOGICAL SCIENCES

THE LIVING UNIVERSE

An Encyclopaedia of the Biological Sciences

S.C.E.R.T., West Bengal
Date 7-5-87
Acc. No. 4005

L'HOMME DE DEMAIN
La Vie et L'Homme, Encyclopédie des Sciences Biologiques
© 1963 by Éditions René Kister, Geneva.
All rights reserved.

English Edition © 1966 by Thomas Nelson and Sons Ltd
36 Park Street London W1
Parkside Works Edinburgh 9
10 Warehouse Road Apapa Lagos
P.O. Box 25012 Nairobi

Thomas Nelson (Australia) Ltd
597 Little Collins Street Melbourne C1

Thomas Nelson and Sons (South Africa) (Proprietary) Ltd
P.O. Box 9881 Johannesburg

Thomas Nelson and Sons (Canada) Ltd
81 Curlew Drive Don Mills Ontario

Thomas Nelson and Sons

Copewood and Davis Streets Camden 3 NJ

Printed in Italy

Man of tomorrow

NELSON

CONTENTS

This eighth and last volume of *The Living Universe* has been published under the direction of Jean Rostand and Albert Delaunay, with the co-operation of Professor Léon Binet, Dean of the Faculty of Medicine, Paris, and that of the Scientific Directors of the work. Dedicated to the Man of Tomorrow, it includes the following chapters:

Jean Rostand	6	*The future of biology*
Etienne Wolff	22	*Modifications of human development*
Albert Delaunay	34	*Tissue grafts*
Alexandre Monnier and Paul Laget	42	*The future of neurophysiology*
Léon Binet	50	*The prolongation of life*
Raoul Kourilsky	58	*The future of medicine*
Albert Delaunay	68	*The future of microbiology*
Rémy Chauvin	76	*The future of the animal world*
Pierre Chouard	84	*Plants in the future of man*
Herman Grégoire	99	*In praise of the future*
	106	*Dictionary of biological and medical terms*
	156	*Some important dates in biology and medicine*

The design on pages 104-5 is by Hans Erni, Artistic Editor of the series

The pre-Columbian statue shown on the opposite page depicts a woman just before childbirth. On the threshold of the future, modern man hesitates and asks questions. But this Aztec woman, a relic of a dead civilization, seems to reply: 'Everything is possible, and the maize on my shoulders, a symbol of my fertility, testifies to this. Mankind lives, dies and is re-born even though civilizations may disappear.'

The future of biology

Jean ROSTAND

Biology, a relatively young science—for its spectacular progress dates only from the beginning of the century—will provide us with many more discoveries and inventions. We cannot be sure that in the years to come it will produce discoveries as fundamental as those of the cell, gene, virus, hormone, organizer, or theories as far-reaching as that of evolution, but there is no doubt that it still has a very long way to go in merely pursuing the lines of investigation on which it is engaged today.

Present-day research indicates the sort of discoveries that will be made in the future. The biologist will discover the activities of new hormones; he will make advances in the analysis of developmental mechanisms; he will determine the genes' methods of action; perhaps he will even learn how to cultivate them as cells are now cultivated; he will learn more about hereditary functions of cytoplasm; he will perfect new methods of induced mutation and will probably succeed in bringing about variations in definite directions; he will achieve in mammals the artificial transformations of sex that have so far been produced only in less highly organized vertebrates; he will make progress in studying the conditions that govern grafting; he will unravel the causes of the process of ageing; and he will increase his understanding of the phenomena of growth and replication which are the essential attributes of all life.

The artificial creation of life

Will the biologist go on from victory to victory until he achieves the supreme triumph, artificial creation of life, the synthesis of living matter, or protoplasm? This is the question that first occurs to the man in the street about the future of biology. Although scientists may not have such an objective, the distance of which they can estimate, directly in view, they cannot deny that they secretly ask themselves what their chances are of reaching it.

All laboratory work tends, as it were, towards the creation of life. It is a long time since the gulf between inorganic and organic chemistry was bridged; since the synthesis of hydrocarbons by Marcellin Berthelot a century ago, many of the more or less complex substances of which living beings are composed have been synthesized. Many highly organized phenomena of life have been explained by physics and chemistry, including fertilization, sexual differentiation, and transmission of hereditary character. No one doubts any longer that inert matter alone is responsible for the working, maintenance, renewal, and reproduction of life, and this 'mechanistic' point of view now inspires and influences all research.

It is admitted furthermore that life itself is an emergent phenomenon; in other words, the properties characteristic of life result from a certain structural arrangement of the elements of matter, and if we were able to reproduce this structural arrangement these same properties would necessarily appear. This complex arrangement never arises spontaneously in nature, or, at least, not to our knowledge, even when starting from chemical compounds of high complexity. In fact, science has never observed the occurrence of 'spontaneous generation'; in this respect Pasteur's conclusions remain completely valid. The problem is therefore whether man will one day be able to *produce* life, which, as he now sees it, can only *reproduce itself*.

Theoretically, and irrespective of one's philosophical views, it would be unjust to deny biologists the possibility of success in achieving the manufacture of the object of their study. For those who believe that life on earth had a natural origin, there can hardly be any doubt: by using technical resources that are continually being improved and having it in his power freely to combine the effects of the most dynamic forces—not excluding cosmic rays—why should not man succeed in reconstituting the conditions which govern biogenesis in the laboratory?

Those who believe life to be of supernatural origin see nothing to prevent the genius of man achieving a feat of which inert matter would have been incapable, if left to itself. For some, man, by creating life, would be imitating nature; for others, he would be imitating the Creator.

It cannot be expected that we shall be able to reconstitute a living cell which, with its nucleus, chromosomes and genes, is already an organized microcosm; but it is a question of solving the much more modest problem of how to make a simple protein or nucleoprotein capable of reproducing itself—in short, something like a virus.

It has often been said in recent years that Fraenckel, Conrad and Williams have succeeded in synthesizing a virus in the laboratory. Nothing of the kind has occurred: their experiments, remarkable and important though they were, consisted in reconstructing the nucleoprotein of a virus, using two of its own constituents—protein and nucleic acid—neither of which do we know how to reconstruct by synthesis. It is a reasonable hope that virus synthesis may one day be biologically feasible, but meanwhile it is impossible to say that this hope will become a reality.

Homo biologicus

What interests so many people about biology are the various uses to which it can be applied and the effects which it can have on our own species. In agriculture, for instance, it helps us to increase our food resources and consequently to face the needs of a population whose continuous and rapid increase is a matter of serious concern. Biology also has a major part to play in the difficult situations arising from the use of atomic energy. The exhaustion of our traditional sources of energy has unfortunately made this necessary: yet biologists constantly remind us of the dangers that atomic radiation has for man's hereditary germ-plasm, though at the same time their science promises to provide us with effective means of protection against its effects.

In a wider context, biology may be said to have instigated all those new discoveries which tend towards the protection of man and the defence of life. The progress made by medicine in the study of micro-organisms, viruses, immunity, and hormones, stems from the work of biologists.

Biology is still a source of inspiration for medical research and it is to biology that we look for the cure of widespread hereditary defects and of malignant tumours, whose apparent increase is one of the terrors of the twentieth century.

Furthermore, by the side of medicine there arose some time ago a new, active, and daring type of human biology, concerned not so much with prophylaxis or with the cure or treatment of disease as with adding something to normal man, either by giving him new powers, or by changing him in his innermost nature and, in effect, substituting a new being in his place, a 'homo biologicus'.

Natural magic

It was at the beginning of the seventeenth century that this new tendency in the history of human relationships first appeared, and it was, I believe, the famous Englishman, Francis Bacon, who was its first advocate.

Bacon was not afraid to attack the firmly established prejudice which held that 'art', that is to say, 'man's addition to nature', was merely an appendage to nature, and that it had no aim other than to complete what nature had already begun, or to remove any difficulties which might prevent nature from working smoothly.

Man, according to Bacon, should think of art in a different and more ambitious way, as a means of completely changing nature, of shaking it to its very foundations. Man-made realities are basically no different from those of nature, and from a knowledge of hidden forms it will be possible to obtain astonishing results capable of achieving all the good promised so deceptively by the practitioners of ancient magic.

Science must become 'natural magic', but magic must lose the sinister connotation that was associated with it as long as men had not learnt how to distinguish lawful ambitions from worthless processes; for in this way medicine will seek not only to preserve and re-establish health and relieve the sufferings of the sick, but also to prolong the thread of life by directly combating the natural process of growing old: and herein lies the noblest aim of medicine, though no doctor has yet given it the consideration it deserves. Its achievement is not to be found in the waters of the fountain of youth or in miraculous elixirs. Leaving such *aurum potabile* to charlatans, the new magicians of science will rely only on a profound knowledge of nature; patiently, persistently, they will study the depredations of ageing in man, in animals, and in plants: they will observe, compare, and experiment.

Bacon is, indeed, the father of modern 'gerontology', but his programme of work was not limited to this. To transform biological types, to bring into being new, larger, more beautiful and more fertile species of greater use to man, to change the colours of plumage and of fur, to make the human body more pleasing and better co-ordinated, to make teeth grow again, all this his programme expected of the science of the future, conceived in the same spirit of daring as today's experimental biology. In this the biologist is at one with Descartes, according to whom man must make himself 'master and possessor of nature' and must search for means of extending human life over several centuries. This impulse already exists. Science progresses more and more vigorously by hypothesis and experiment, confident in itself and its decision to improve on nature.

René-Antoine Ferchault de Réaumur, having established that it was possible to prolong the life of a chrysalis by refrigeration, then considered in 1745 whether it would not be possible, by using analogous methods, to slow down the vital processes in man and so delay death, an idea which was later to be taken up by John Hunter in 1753. The Abbé Lazzaro Spallanzani, in 1789, was the first to succeed in the artificial insemination of toads and frogs, and then of dogs. The enthusiasm of his friend Charles Bonnet, was expressed in these words: 'This is one of the greatest innovations that has been presented to naturalists and philosophers since the creation of the world. Nothing can be more accurate nor more firmly proven, nothing as beautiful

Opposite page: Man is on the point of launching out on the conquest of space. But when will he achieve the creation of a single cell that is endowed with the qualities of life? (Photo Lod).

or as new, as this experiment.' Bonnet foresaw later applications of the experiment to the human species; nor were they to be long delayed. In 1824, Etienne Geoffroy Saint-Hilaire believed he had induced artificial deformities in chickens. He attached great importance to this because he believed that by procedures of this kind, variations in biological types could be achieved: it was, he believed, nothing less than 'experimental transmutation'. Then—and only a few of the stages in this progress towards creative biology are mentioned here—in 1863 Paul Bert experimented with animal grafts, and Claude Bernard prophetically named the physiologist the 'inventor of phenomena', the 'overseer of creation'. Soon the internal secretions or *hormones* were to enter the biological scene and to provide biologists with a powerful means of modifying vital processes, for hormones are the very substances used by nature. In them the biologist possesses one of the great secrets of vital processes.

In 1889, Edouard Brown-Séquard, having performed experiments on himself (at the age of seventy-two he had subcutaneously injected himself with extracts from the testes of a guinea-pig and a dog), announced that it was possible by this means to reverse the changes brought about by senility and that the tissues which deteriorate with age could once more be made comparable with those of an adult. This was the first scientific attempt to delay death.

From then onwards, the use of hormones began to reveal the extraordinary diversity of their powers; by using them, it became possible to influence growth, sexual differentiation, sexual maturity, and pigmentation.

Meanwhile, Jacques Loeb achieved the chemical fertilization of sea-urchins by replacing the spermatozoon with suitable solutions of salts. He suggested, after his first successes, that the same method could be applied to women. Elie Metchnikoff approached the problem of ageing and natural death by procedures different from those of Brown-Séquard; he looked to science to rectify the many 'disharmonies in man'. Then, in 1910, Alexis Carrel, by making use of the technique of tissue culture invented by Ross G. Harrison, revealed the potential immortality of cells in the more highly-developed organisms.

Fulfilling the most persistent of human desires

Today, in 1965, the idea of transforming living nature, and especially human nature, has become one of the current themes of biology. The thesis outlined by Bacon is being put into practice. Every day, biological science shows its innovating and creative character, experimenting and exploring, producing previously non-existent combinations, and introducing new phenomena into the world. Biology is supplementing nature, and there is not one of its innovations that is not quickly scrutinized for its possible applicability.

Until now man has been little affected by the results achieved by experimental biology. Astonishing operations are continually performed in the laboratory—changes of sex, operations on the ovum, manipulation of the germ cells or the embryo, induced mutations, modification of the rate of growth, acceleration of sexual maturity, grafts that result in the production of living beings constructed like mosaics, etc—yet almost nothing of all this has yet had any repercussions on man. The only way in which biology has affected man is by artificial insemination. But biology can be expected to be much more enterprising in the future.

To be rejuvenated, or simply to age less quickly, is the oldest and the most persistent of human desires. Since the time of Brown-Séquard and Metchnikoff, there is nothing that the imagination has not contemplated with a view to retarding the processes of senility and to revitalizing organisms that have deteriorated through age.

Embryonic extracts rich in stimulating substances or trephones, hormones, chiefly sexual hormones (folliculin and testosterone), the blood of adolescents, urine of suckling infants, living cells of sheep (Niehans' method), extracts of placenta, biogenic stimulins (Filatov's method), stimulating serum of connective tissues (Bogomolets' serum), royal jelly of bees, novocaine derivatives, etc—not one of these has produced convincing results, and it is doubtful if they ever will. But although biology is at present unable to counteract the effects of ageing, the probability is that one day it will have the means to do so.

Organ banks

We do not know what old age actually involves; it is partly due perhaps to a slow poisoning of the cells; it is always more difficult to cultivate tissues *in vitro* when they are derived from an old organism than when they are derived from a young one; but the difference between them is less and may even disappear if the senile tissues, before they are placed in culture, have been exposed to a digestive enzyme such as trypsin. It is as if this 'cleansing' process had rejuvenated them. Perhaps there is hope in this for the treatment of old age, either by injecting appropriate enzymes into the body, or by removing organs or tissues from the body, treating them with such enzymes *in vitro,* and replacing them after treatment (for example, rejuvenation of the blood by cleansing the bone marrow).

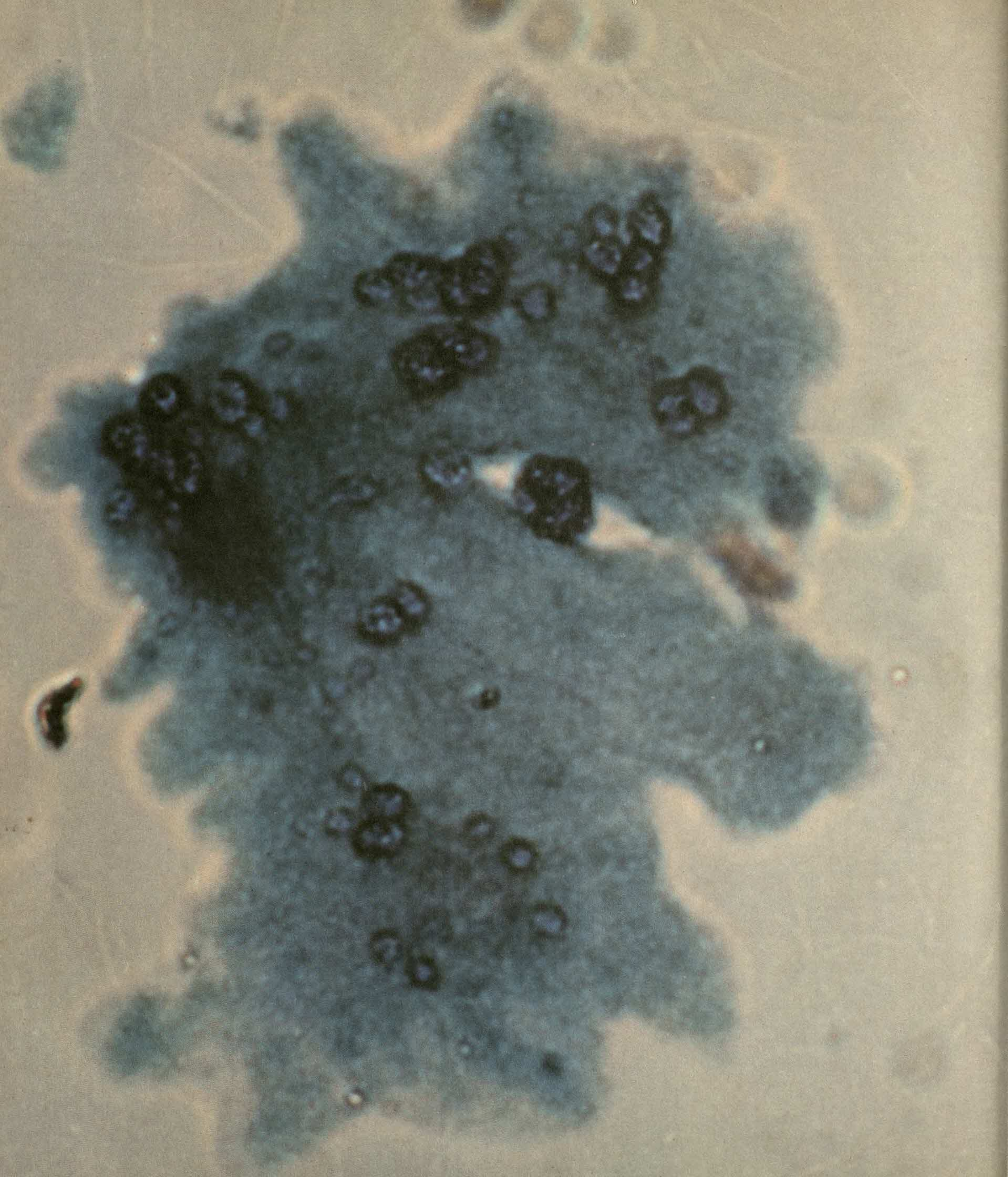
Whatever the mechanism of ageing may be, a constant factor is the hereditary tendency to longevity: certain families, certain genetic stocks, are distinguished by an unusual proportion of 'Methuselahs'. This has naturally suggested the possibility of extracting anti-senile substances from the tissues of old people, such substances having demonstrated their genetic aptitude for longevity. The idea is that large quantities of these precious tissues could be cultivated in special laboratories.

Another hope, fairly soundly based, relates to various methods of refrigeration. Experiments on fungi and insects suggest that refrigeration carried out over a considerable period can have a rejuvenating effect. It is possible to lower the internal temperature of a mammal markedly without causing death. This is done in such a way that it reduces the mammal to a state of torpor rather similar to that of hibernating animals (marmots, dormice, hedgehogs). If the internal temperature of a rat is lowered to 10-15°C, the animal becomes completely immobile and insensitive and no longer reacts to external stimuli. If it is warmed again after twenty hours, it returns to its normal condition; and, according to experiments made by Jean Giaja, it seems that refrigeration of this sort may even increase cardiac resistance.

We cannot exclude the possibility, says Giaja, that one may be able to produce in man, as in the rat, deep lethargic hypothermia, with extreme slowing down of the vital processes; treatments of this kind, repeated periodically, of 'sleep induced by cold', might perhaps have favourable effects.

Even though it may be impossible to submit the human organism to treatment of this kind without danger, it might be possible in the future to refrigerate tissues and organs that have been removed and to replace them by means of grafting after they have been rejuvenated. The idea of rejuvenation 'piece by piece' leads on to a consideration of grafting, which offers a hope for gerontology that is by no means negligible.

It is not a new idea to replace a worn-out organ by an intact one removed from a younger person, but up to now this method has not been generally used because the transplantation of organs is doomed to failure. If an organ is transplanted from one individual to another, the graft excites a vigorous defence-reaction in the recipient which ends in necrosis and rejection of the foreign organ.



Recent progress in grafting experiments suggests that this obstacle of individual intolerance will sooner or later be overcome, either by preparation of the organism for acceptance of the graft, or by subjecting the graft to treatment which will make it acceptable to the host; or alternatively by using grafts derived from very young organisms, or by implanting the graft in a site particularly favourable to it, where it will be protected against the defence-reactions of the recipient.

A new era in human grafting will begin when it becomes possible to replace any kind of organ or tissue by others from different donors. The individual 'machine' would then no longer be comparable to a special make of motor car, but to a 'standard' model for which replacements could be found at any garage. Organs of persons who died young and in good health would be preserved and stored in organ banks for the pancreas, kidneys, heart, testicles, ovaries, bone marrow, and skin.

When the sleeper awakes

The problem of preserving these organs presents no special difficulties because techniques already exist by which it is possible to keep alive for several months, or even several years, cells (spermatozoa, etc) or tissues (blood, bone marrow, skin); to do this it is sufficient to impregnate them with dilute glycerine before subjecting them to a low temperature (−80°C, the temperature of solid carbon dioxide, or even −196°C, the temperature of liquid nitrogen).

In certain cases tissues can be freeze-dried (cryodesiccation or lyophilization) to preserve them in the dry state: as soon as the tissue is moistened again, it comes back to life and starts functioning again.

By means such as these it would be possible even now to preserve human semen for artificial insemination which could be performed ten years, a hundred years, or perhaps even a thousand years after the donor's death. Some far-seeing biologists have even proposed that stocks of human semen should be established which could be protected in the event of atomic war.

Cells and tissues preserved by refrigeration are virtually in a state of *suspended animation*; indeed, it seems that in such cases a kind of ambiguous state may have been achieved which is neither life nor death, and for which Isidore Geoffroy Saint-Hilaire said that there is no name in any language. Perhaps it is not too fanciful to imagine that one day we shall succeed in achieving for the whole organism what is already being done for its various elements.

According to Louis Rey, who is one of the pioneers in the study of this subject, this amazing result could be attained by the discovery of a suitable balance between preliminary freezing, choice of protective liquids, drying temperature, degree of dehydration, and the process of reconstitution. In this way, thanks to biology, man would realize one of his oldest dreams, the *suspension of time*, a dream which has been echoed in many stories, for example, Poe's *Dialogue with a Mummy*, Oscar Wilde's *The Picture of Dorian Gray*, and H. G. Wells' *When the Sleeper Awakes*. It will become possible for a man to economize in the expenditure of his life's capital by making voluntary pauses: thus he would have a future such as he could never know if he were to live his life continuously. One thinks of all the people suffering from incurable diseases who could preserve themselves in this way while they waited till medicine had found a means of curing them. Also, it would be possible for this 'life suspension' to be used by astronauts to overcome the difficult conditions of journeys into space; an automatic apparatus would enable them to be 'resuscitated', with the necessary precautions, as soon as they reached their destination.

Perhaps, if biology is able to give this

Opposite page: Amoeba, a unicellular animal, one of the simplest of all in its organization, nevertheless has a chemical structure of such complexity that the biologist cannot hope to construct a copy of it: to do this would be the greatest victory of the man of tomorrow. (Photo Lod).

help to astronautics, astronautics may have something to offer in return by revealing forms of life as yet unknown to biology.

Systematic cultivation of human tissues

The modification of human heredity is yet another of the reasonably venturesome hopes of biology. In the first place, one may think of methods of eugenic selection analogous to those which are used with constant success for improving species of animals and plants. The same methods would make it possible to raise the genetic level of our own species appreciably within a few generations. The application of such methods of selection to human beings would not present any biological problem, although at present it would run into grave psychological and social difficulties. Other more direct methods of modification can be imagined, which would act on the genetic substance itself as it passes from parent to offspring and ensures the transmission of hereditary characters. Not only have the particles or *genes* responsible for this transmission been identified in the chromosomes of the cell nucleus, but their chemical constitution was elucidated a few years ago; their essential component is a certain acid, *deoxyribonucleic acid,* or DNA.

In some cases it is possible to alter the composition of DNA—'the noble cell substance'—or *heredine* if one may so call it—by subjecting the cell to the 'inductive' action of DNA taken from another source. The effect is as if this foreign DNA had substituted itself for the autochthonous DNA and incorporated itself into the hereditary constitution of the cell. This phenomenon of chemical hybridization is called 'controlled mutation'; it is, in effect, an example of a type of artificial mutation quite distinct from the classical type in which the mutagenic agent (eg, X-rays or mustard gas) causes random variation; in *controlled mutations* the mutagenic agent intervenes in a strictly *specific* manner; it effects the transmission of a certain type of hereditary constitution to another, forecast and designed in advance. Mutations of this kind have already been obtained in bacteria, but their success in higher animals is not so well founded.

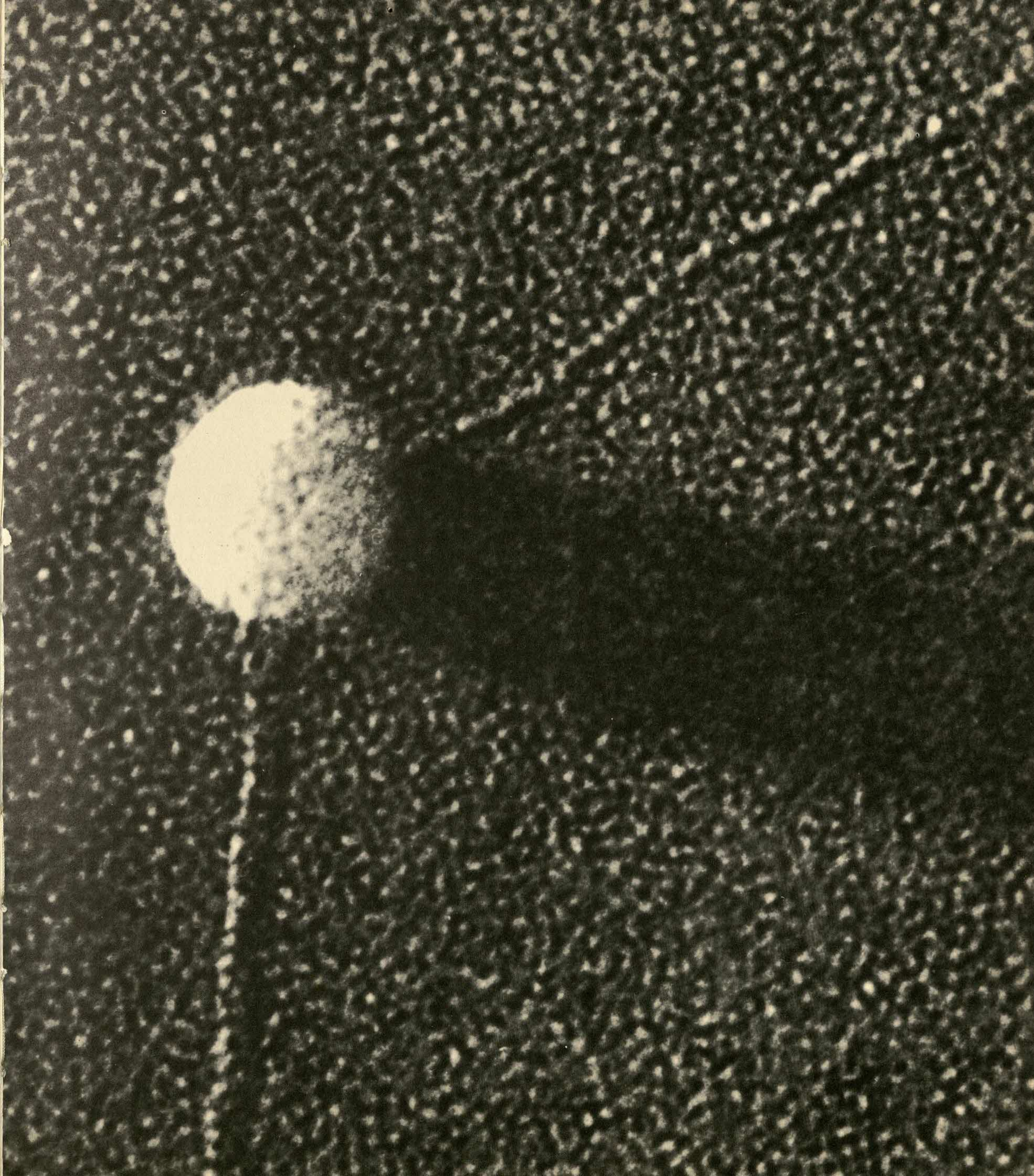
According to Jacques Benoit and his colleagues, a new race of ducks (snow-white) appeared among some descendants of strictly pure-bred Pekin ducks under the inductive influence of DNA derived from khaki ducks. As it was not possible to repeat the experiment, either in ducks or other animals, a legitimate doubt exists as to the interpretation of the observed facts. But whatever their validity and significance, it is probable that one day we shall be able to perform on one of the higher animals the experiment that Benoit and his colleagues believe that they carried out successfully on Pekin ducks. Obviously, the temptation to apply so promising a method to man will be irresistible.

It is not unreasonable to suppose that the time will come when it will be possible to modify heredity—or, more precisely, everything that is chromosal and depends on DNA—by the use of carefully chosen heredines. The way will then be open not only for the cure of hereditary defects, but also for the improvement of normal characters: physical stamina, longevity, beauty, intelligence, and resistance to disease. Human tissues would be cultivated systematically in order to extract high quality DNA from them. Abundant cultures would be obtained from every exceptional example of the species. Perhaps biology will also learn to cultivate the genes individually, so that there may be greater precision in the handling of the inductive material. This would not be confined to DNA taken from man: it would be synthesized DNA, the properties of which would be even better than those of the best forms of DNA provided by nature.

The dawn of psychochemistry

One day perhaps, biology, by means of DNA will make it possible to improve man's intelligence; but other methods, not involving

Opposite page: Deoxyribonucleic acid, or DNA, *the molecule of which is here seen magnified 625,000 times by the electron microscope, is the 'noble substance' of the cell and the bearer of hereditary characters. If the biologist should succeed in modifying its composition, he would acquire the power of influencing heredity and, through this, of transforming human destiny. (Illustration by Dr Cecil E. Hall, Massachusetts Institute of Technology, Cambridge, U.S.A.).*



Opposite page: The large pyramidal cell, an element of the cerebral cortex, is one of the structures involved in thought. Will the 'psychochemists' of the future succeed in modifying its metabolism and thus in 'superhumanizing' our species? (Photo Lod).

genetics, seem to be capable of effecting this possibility. Certain forms of hereditary mental deficiency are caused by a disturbance of the metabolism of the cells of the brain. So if chemical conditions are sometimes responsible for mental deficiency, why should not other chemical conditions produce an improvement in the mental faculties? For instance, uric acid, acetylcholine, serotinin, and various diastases, are among the 'natural drugs' whose intervention is suspected in the functioning of nervous tissues. But 'psychochemistry', which will probably produce many surprises in the future, is at present only in its infancy.

There is also another procedure by which it would seem theoretically possible to increase man's intelligence. This would be by increasing the number of active brain cells. It is impossible to establish a very precise relationship between the number of cells and the degree of intelligence, but it is reasonable to suppose that a brain better equipped with cells would offer possibilities of even better functioning.

An experiment by the biologist Stephen Zamenhof consisted of subjecting rats, during their embryonic life, to the effects of a hormone (the growth hormone of the pituitary); when the rats were born, their brains were bigger than normal and more abundantly equipped with cells; this superiority they maintained throughout their lives. They did not appear, however, to be more intelligent than their fellow rats. Unusual experiments such as these should be followed up, even though they may be doomed to failure, because it is possible that the brain of each species has attained its structural and functional optimum. Nevertheless, these experiments may yield the first indications that will lead to the 'superhumanization' of our species.

Psychological effects cannot be excluded. In the light of Konrad Lorenz's experiments—from which it was discovered that a bird's behaviour can be influenced in all its subsequent conduct by the first visual images that it receives when it leaves the egg—it is inevitable that one should dream of the possibility of modifying the psyche by stimulation applied immediately after or even before birth. The human foetus has a sensory life; no one can foretell what effect might be produced by skilled prenatal 'education'. Whether it were produced by chemistry or by psycho-conditioning, intellectual superiority thus acquired would clearly not be transmissible to the descendants; the 'superiority' treatment would have to be renewed in each generation.

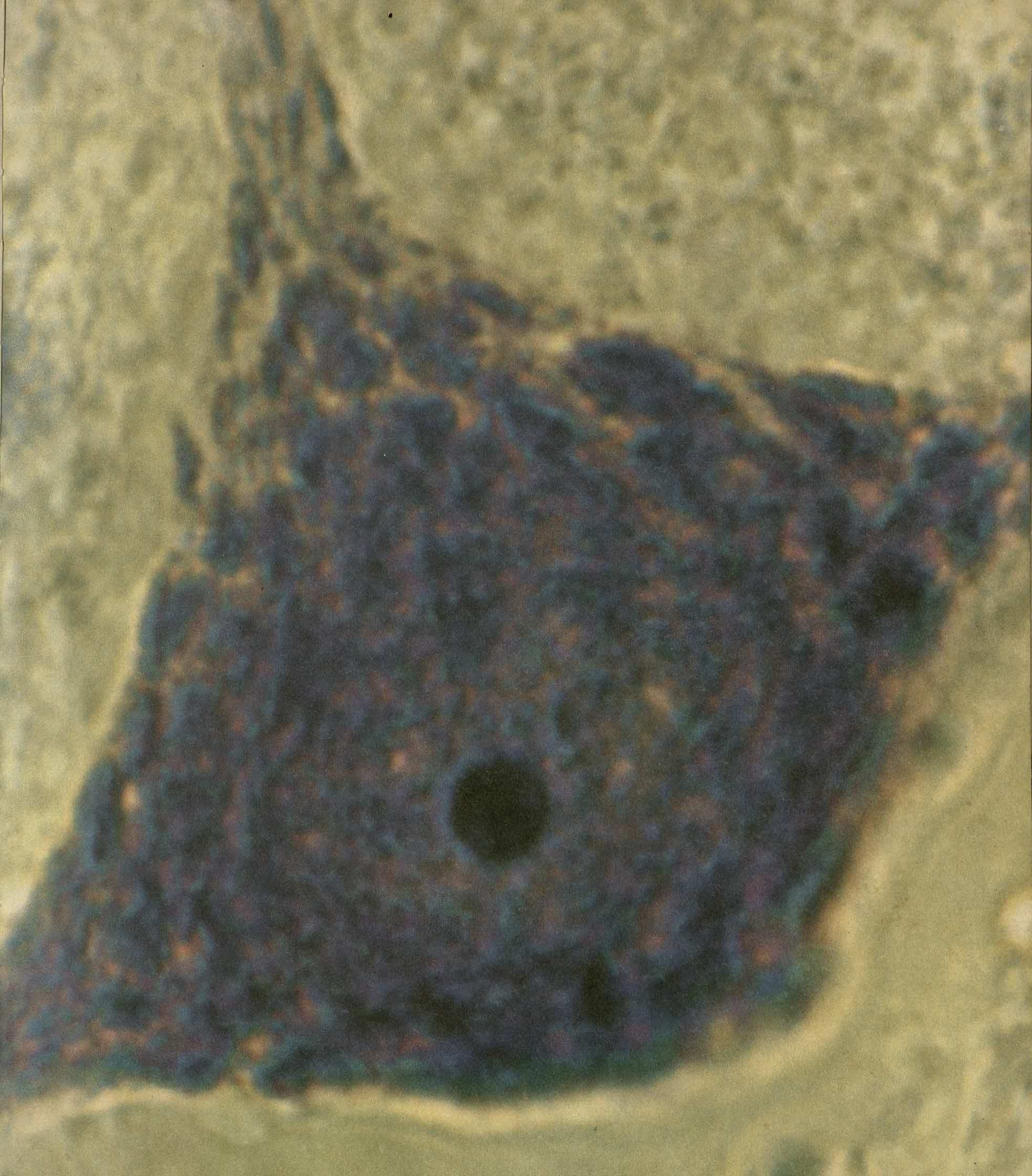
Determination of sex

In addition to these hopes for the future, chief among which are the prolongation of life and the perfectioning of the mind—biology gives a glimpse of some solid, if secondary, achievements.

The problem of sex determination is certain to be solved within a few years because the precise way in which this determination operates is now known, and all that remains is to find a means of separating from the semen the sperms that produce boys from those that produce girls.

Vast progress in the field of sex hormones is also to be forseen. It is the sex hormones that enable us to influence the sexual fate of an embryo, either to feminize one that is genetically male or to masculinize one that is genetically female.

The methods of parthenogenesis (virginal reproduction)—already applicable to lower vertebrates (amphibia) and to certain mammals—great difficulties notwithstanding—will undoubtedly be extended in the course of time to our own species. But as long as reproduction without a father involves—as it does in the case of the female rabbit—a surgical operation, it is unlikely to become common practice; but less drastic methods can be envisaged, as for example, the injection of stimulants. Applied to the human species,



parthenogenesis would produce only girls; nevertheless, if we were to insist on producing boys without fathers, 'parthenogenetic' embryos could be subjected to a masculinizing treatment.

Present-day research on 'organ culture' suggests that it will one day become possible to cultivate a human embryo entirely outside the uterus in a kind of artificial incubator. This 'ectogenesis', or 'test-tube pregnancy' would have the advantage—if such it may be called—of putting the human embryo at the mercy of the biologist. It would then be possible, for example, to consider direct operations on the brain with a view to favouring the growth of a particular part. Other innovations that might be contemplated are the artificial production of twins (identical or otherwise), the doubling of the number of chromosomes, the increase of regenerative powers, and the lengthening of the period of pre-puberty, etc.

Dramatic future choices

None of these modifications of man's organic status will occur without objections being raised, difficulties created, and apprehensions aroused. The law will have to be revised (if only to provide for the legal problems which posthumous insemination would create), particularly because of the potential dangers that would face everyone, dangers not only for society, but for the individual concerned, and for the species.

If there is a single natural and universal wish, it is for the prolongation of life. But could society afford the luxury of maintaining so many old people? Only if prolongation of life were matched by a prolongation of stamina, though nothing could be less certain; perhaps all that would happen would be a prolongation of the phase of decrepitude and inactivity. In any case, would not the duty of making life last longer conflict with the duty of producing new lives? Should we allow our disinclination to let people die prevent others from being born?

The arbitrarily willed determination of sex and birth without a father would also present serious social difficulties. Is there not something disturbing in the calculated exploitation of biological control through modification of the human body by hormones or DNA? Surely our instincts and deepest sensibilities would be shocked by the thought of bringing beings into the world who have been made to measure and designed in advance?

The philosopher, Guy Durandin, has partly explained the fundamental reasons for our sentimental resistance to modifications of

⁂

man by man: 'With the help of science, woman will no longer receive her child; she will order it with masculine or feminine sex, blue or brown eyes, blond, brown or chestnut hair. All that will need to be done will be to delete inapplicable words on the laboratory's order form. We still have a tendency to defend ourselves against such notions, to treat them ironically, but we should try to understand why they trouble us. It is simply that they lead to the negation of human nature. It is not possible for us to wish for anything except from a natural basis which we accept as "given", which does not depend on us, and which we cannot alter. If man can be modified at will, if there is no longer such a thing as human nature, there can no longer be a human destiny, and we shall have reached the point of absurdity. If human nature no longer exists, then neither do good nor evil; human desire will be meaningless, as it would be the desire of nobody.'

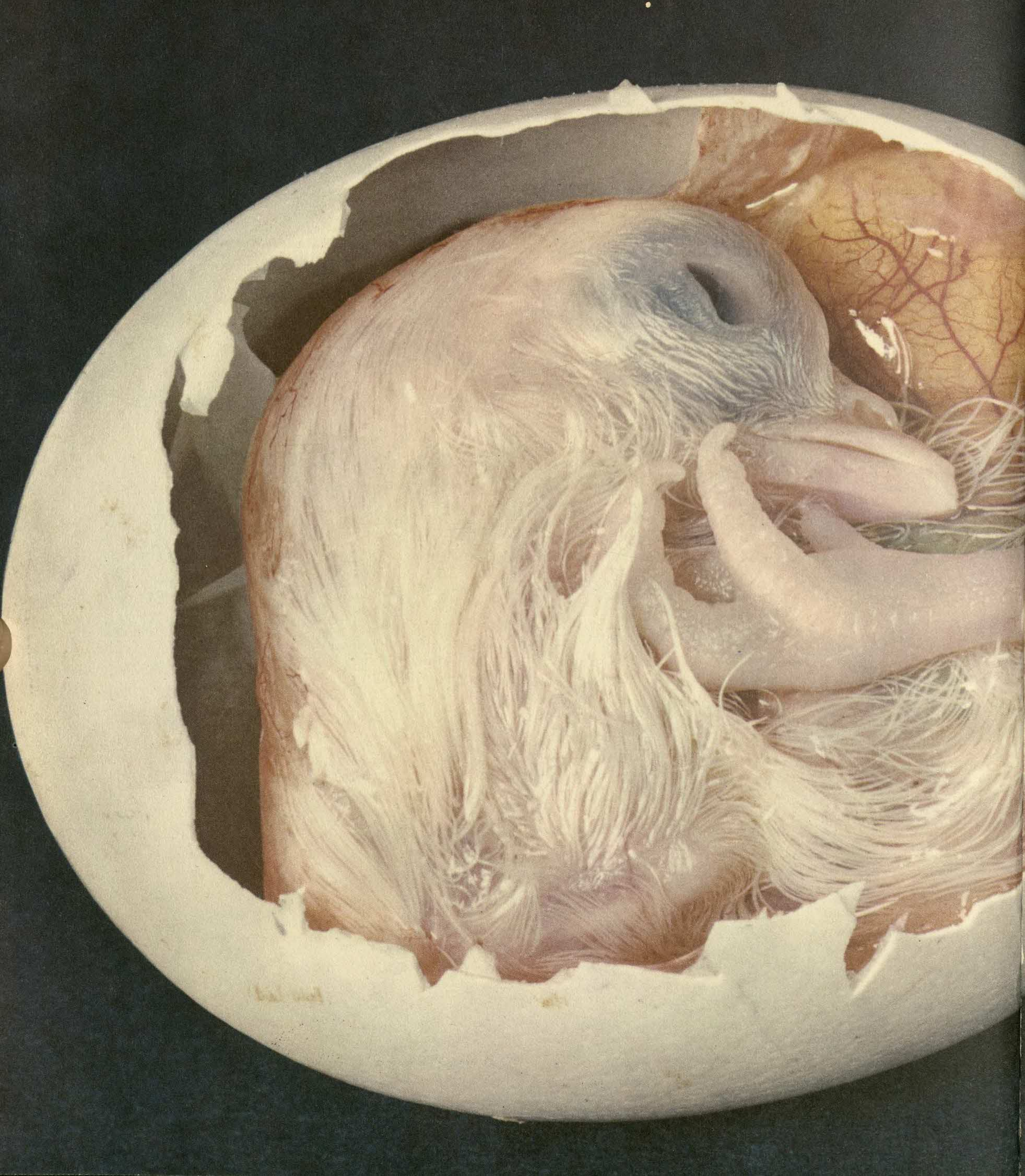
What of the prospect of a superman, who would perhaps supplant or enslave us? Is it the ruin of humanity that is being silently prepared in the laboratories?

To these grave questions each of us—as always happens—replies according to his feelings. Some biologists are frankly disturbed; others view without undue alarm the advent of this strange future and have confidence in the pliancy of man and in his unlimited powers of adaptability. Others again—and they are perhaps the most numerous—would wish a distinction to be made between the promises of biology that offer hopes and those that contain threats, those that can be chosen without repugnance and those that must be rejected. But by what criteria will the wisest choice prevail?

Some say that man must take from science only that which is compatible with nature, others that he must take only that which is humanizing—only those things that will raise him to a superior degree of humanity.

No one can fail to see the difficulty of agreeing on what is 'natural' and what is 'humanizing'. But even supposing that agreement is reached among the specialists, how can we make their decisions respected? Shall we ask some superior authority, a 'council of elders', to control the application of discoveries, or shall we, out of fear that minorities may obstruct, rely merely on the good sense and judgement of the majority? One thing is certain: the collective conscience will be increasingly faced with problems of this kind. No one can guess how it will solve them. Mankind of tomorrow will be faced with dramatic choices, for the whole design of human destiny may depend on what use man will make of his biological knowledge.

⁂



Can the results of experiments carried out on animals be applied to man? This is the question asked by Etienne Wolff at the beginning of the chapter which follows. It is the object of intensive research to which embryologists devote themselves, for after a living being has left its egg it is too late to make any profound changes in its destiny (Photo Lod).

S.C.E.R T., West Bengal
Date 7-5-87
Acc. No. 4005
S.C.E.R.T., West Bengal Library Calcutta 25/3, B. C. Road
STATE INSTITUTE OF EDUCATION BANIPUR

Modifications of human development

Etienne WOLFF

Can the results of present-day experiments performed on animals be applied to man, if not now, then at some time in the future? It is always hazardous to forecast and perilous to extrapolate, and such speculations must be made with the utmost caution.

Can man be changed? In his preface, Jean Rostand draws attention to the possibilities and dangers of applying to man the data recently derived from biology. He emphasizes—and we agree—that the biologist's role is not the same as that of the moralist, but that his duty is to advise and anticipate. We ask the reader not to forget this in the pages that follow, in which some feasible forecasts are presented as possibilities, but without any opinion being given as to their moral values.

The question of changes in man can be looked at in two different ways: Does the human species tend to evolve spontaneously? Can man influence his own nature and alter his destiny? The first question concerns the species, the second chiefly concerns the individual.

Does the human species tend to evolve?

On this question one can be brief. It can be said, as many biologists have maintained, that man represents a culmination, the limit of evolution, or that he is a malleable intermediate form, a perfectible being containing within himself the seed of a new kind of future.

In support of the first hypothesis it can be argued that man has been changed hardly at all, either physically or intellectually, for tens of thousands of years, since the Upper Paleolithic Age, in which he was represented by beings similar to those of today (Cromagnon, Grimaldi, Chancelade).[1] But if human progress is to be assessed objectively, as one would study the evolution of animal societies, one cannot fail to be struck by a succession of cultures and habitats that suffice to classify man as a being who has become racially transformed.

It should be pointed out, however, that none of man's cultural or technical attainments are transmitted from one generation to another; in each generation the apprenticeship must be repeated, contrary to what is to be observed among animals which carry on an industry, such as bees, ants, termites or spiders. Mental faculties, if they have not been trained during the first years of life, cease to develop and the individual relapses irretriev-

---

(1) *It may be recalled, however, that although man has hardly changed since the Upper Paleolithic period, between the Lower and Upper periods he had undergone considerable changes, passing through the stages between* Pithecanthropus *and modern man.*

ably into the animal state, as is shown by 'wolf-children', or children who have been sequestered and withdrawn from all social intercourse. This is not say that man's intellectual aptitudes have not altered during the course of generations, but it is certain that this has not been built into his genetic inheritance.

In support of the second hypothesis it may be suggested that physically the human species is somewhat primitive; its teeth and the way they are arranged, its limb structure and its plantigrade walk, are fairly similar to those of the less highly developed vertebrates. Such an argument need not be disputed; it would be easy to object that a species that is badly adapted to leaping, running, flying, swimming or to a subterranean life, is not necessarily a primitive species. It is pointless to remark, on the other hand, that the character of the brain and the human skull, are certain guarantees of a high level of evolution. We should admit that the human species, with its mixture of primitive and 'well-developed' characters, is susceptible to modification. How can one conceive the possibilities of such further evolution?

We know that the human brain contains nine thousand million pyramidal cells, which are the product of thirty-three successive cell divisions. The number of mitoses of the nerve cells is fixed and therefore the number of nerve cells in an organism, although considerable, is not unlimited. Suppose that an experimental procedure or a spontaneous mutation could bring about a further division: the number of cells in the cerebral cortex would then be doubled. Such a change could conceivably result in a considerable enhancement of the individual's intellectual faculties.

In the present state of science, such a supposition is utopian, fantastic, although it is not absurd, because experimental embryological researches have shown that certain tissue secretions and tissue extracts can cause an intense aberrant multiplication of the sympathetic ganglia neurones of chick embryos.

Among such tissues and active substances are mouse sarcoma, snake venom, and an extract of rats' salivary glands. By treatment with these substances, organs that normally have a poor nerve supply are crammed with nerve cells and nerve fibres. To be sure, this extraordinary proliferation is rather uncontrolled; it affects only the ganglionic neurones. But the possibility that 'neurotrophic' substances could have an analogous effect on the cells of the cerebral cortex cannot be ruled out.

Can the nature of the individual be modified?

If we cannot change the human race immediately, is it possible to consider means of acting on individuals to correct and improve on nature and to put right some blemishes and errors? There can be no doubt of the answer, for progress in science and medicine has already contributed greatly to the solution of these problems. We need only think of the increase in the expectation of life, raised in a few decades from fifty-five to sixty-five years, or the cure, prevention, and in some cases, elimination of certain infectious diseases, and of progress in nourishment and bodily hygene. Are there any other possibilities of applying biological discoveries to the human species? Today we know how to perform artificial insemination in human beings by a simple technique which is used in special cases, such as marital infertility. There is no danger of this practice becoming general, because of the opposition raised against it on moral and religious grounds, and individual preferences for other methods of insemination. But supposing that it were imposed by some authority that exercised strict control over births by the prohibition of certain unions and a regimentation of pregnancies: subsequent generations would be greatly changed as a result of such eugenic practices. We now know how to preserve the semen of man and of domestic animals for more or less prolonged periods, and how to convey it over a distance. If it could be kept in reserve for generations—a feat which it is not yet possible to achieve—we would then be able to use for a long period and for several fertilizations, the germ cells of an individual whose physical and intellectual qualities seemed deserving of choice.

Let it be emphasized that we do not wish to pass a qualitative judgment on this, we are merely envisaging possibilities. This leads us to the question of eugenics.

Eugenics, or applied genetics, may be considered from the points of view of negative eugenics and positive eugenics. The aim of negative eugenics is to avoid certain hereditary defects, constitutional diseases, and serious malformations, by advising against or forbidding certain marriages. Defects that are distressing both to the individual and to society could thus be eliminated. Special attention would be given to defects that are caused by a dominant gene, which will undoubtedly reappear in each generation, or those defects that are unavoidably transmitted to one sex or the other.[2] In this way, the births of abnormal or exceptionally feeble beings would be avoided, beings who would be doomed to suffering, to a vegetative life or an existence on the fringes of society, as, for instance, in the case of those suffering from haemophilia, Huntington's chorea and achondroplasia, limblessness, *xeroderma pigmentosum*, congenital cataract, optic atrophy, and certain forms of mental derangement, blindness, deafness and dumbness. The problem of recessive defects is more debatable, for these appear only if the abnormal gene exists in both parents. Also, this kind of anomaly affects only some of the descendants; in the simplest cases, twenty-five per cent. Such parents can have children all of whom are healthy, for the calculation of probabilities shows that this percentage is valid only for large numbers. On the other hand, such parents could produce only abnormal children. We are therefore faced with a controversial question. It must be said here that although consanguinity does not in itself produce any defect, it favours the recombination of recessive genes; where it is known that such defects exist in the ancestors of a family, the possibility of their reappearance is certainly to be feared in marriages between near relations. When such marriages are contracted, unsuspected hereditary diseases may appear. It would be useful, and is indeed necessary, to record data about the heredity of the individual in successive generations. Each member of society ought to have a 'genetic file', just as most people have a national health insurance card. Research into blood groups would be a primary element in this kind of record.

Positive eugenics would involve the selection of favourable physical or intellectual characters, the establishment of birth control, and, let's face it, the choice of 'reproducers'. Disregarding whatever may seem shocking in this idea, as well as memories inevitably evoked by atrocities recently perpetrated by a deluded nation in the name of so-called eugenics, it should be realized that man would possess a powerful means of influencing the destiny of his descendants if each individual had a detailed genetic record kept up to date throughout the generations. Would this be a good or a bad thing? By what criteria, in the name of what principles, and according to what norms would selection be applied, and in what manner? These questions are formulated without any attempt being made to answer them. We must envisage all the possibilities that the progress of science can provide for humanity.

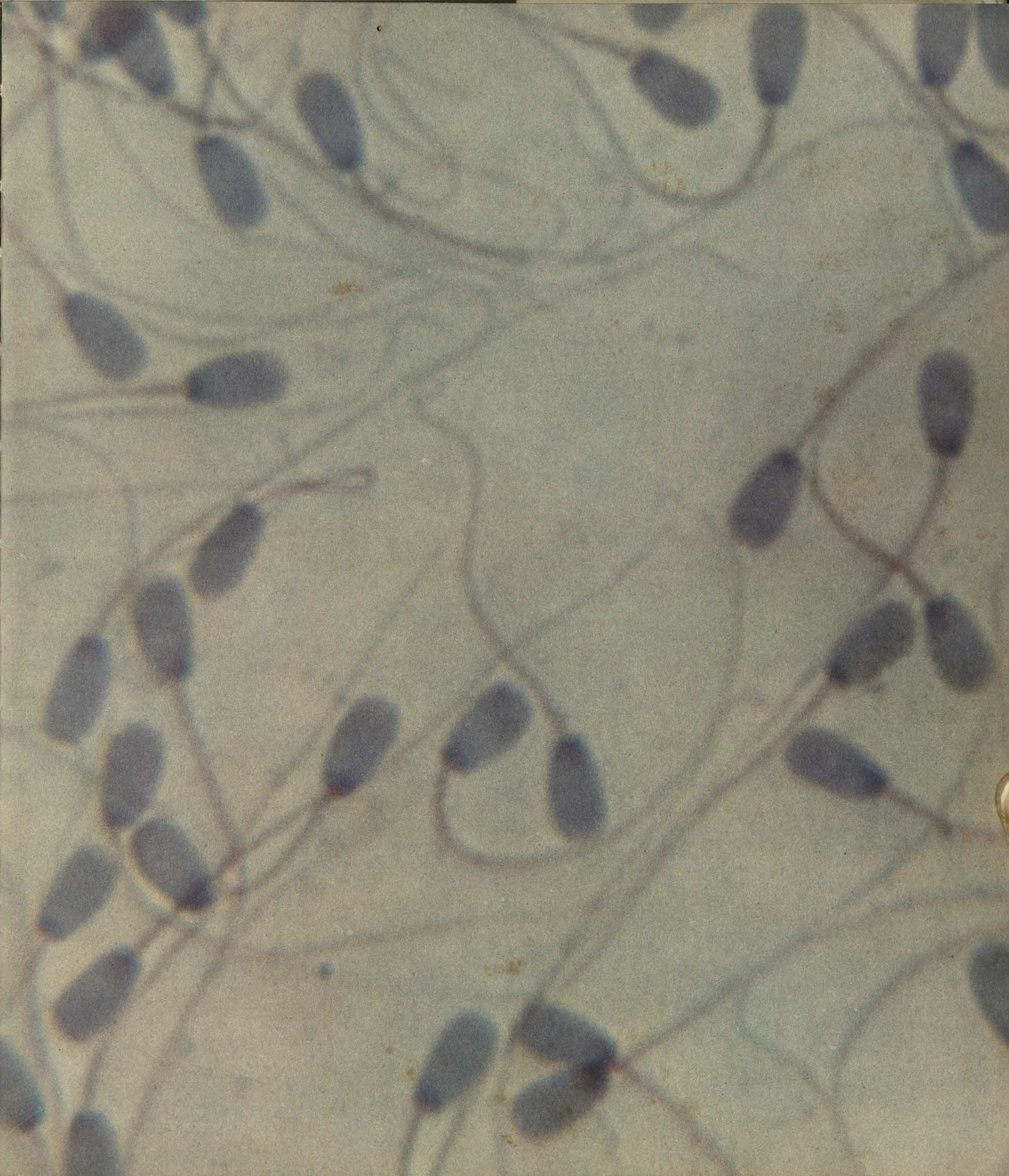
Sex-determination, parthenogenesis, and the production of twins

Sensational experiments carried out during the last thirty years on groups of vertebrates have led to the hope that it may be possible to achieve the determination of 'sex at will' in the human species. Two methods of doing this can be envisaged, which correspond to two lines of research: to intervene at the very moment of fertilization, by imposing the

Opposite page: We know today how to preserve the seminal fluid of man and that of domesticated animals for prolonged periods, and how to transport it to a distance. If it were to be supposed that one could place in reserve for generations the spermatozoa of the bull—the curious arabesques of which are illustrated on the opposite page—or those of a human being, what possibilities this would open for the future eugenicist! From then onwards he would be able to select animal species as precisely as plants can now be selected. (Photo Lod).

---

(2) *In a number of countries, and in particular in several of the United States of America, sterilization is legal and obligatory in certain cases of hereditary diseases.*



male or female chromosomal constitution on the egg; or, by means of hormonal treatment, to reverse the sex of an embryo whose genetic constitution has already been decided.

In animals, the second type of research has given more certain and more numerous results than the first. With the help of grafts of the gonads or injections of hormones, the sex of certain embryos has been more or less reversed. In some groups of animals, for example, fish and amphibia, reversal has been complete and definitive. Several biologists have succeeded in causing former males to lay eggs and former females to discharge spermatozoa, also males to fertilize former males and former females to fertilize females. Such successes may have awakened the hopes of some of our contemporaries, who wish either to have children of a particular sex, generally boys, determined in advance, or to change their own sex at the adult stage. Uusually it is masculinization that is desired, as I can prove by the many letters on this subject that I have received. Those who entertain such hopes must be undeceived.

It can be said definitely that radical and functional changes of sex have been achieved only in young embryos. Also, although the lower vertebrates have provided some instances of complete and definitive reversals of sex, the higher vertebrates, although they have been changed by such treatment, have never been completely or permanently changed. Young male chickens, perfectly feminized by the injection of the female hormone before hatching, progressively recover their original sex. The embryos of rodents—rats, mice and guinea-pigs—have been more or less changed; but only the genital ducts and the copulatory organs have been modified in the male or female direction; it has not been possible so far to alter the genital glands.

Thus, instead of achieving a complete and lasting transformation of the sexual organs, only 'intersexes' have been produced; that is to say, individuals that are sexually malformed and often unable to reproduce. Attempts to transpose to man the results obtained with animals, would involve a risk of producing monsters of this kind. Or else a transformed person would always run the risk of recovering his genetic sex, unless hormonal treatment were given regularly to maintain the assumed sex.

Is it possible to impose a male or a female genetic constitution on an egg at the time of fertilization? In mammals, all eggs have the same constitution of sex chromosomes; ie, they all contain an X-chromosome; some of the spermatozoa, on the other hand, carry an X-chromosome and some a Y-chromosome. The determination of the male or female character of a fertilized egg results from the union of the egg with one or other type of spermatozoon. Is it possible to identify the X- and Y-spermatozoa and to separate them? Nothing enables us to recognize the spermatozoa of one kind or the other while alive. Research workers some years ago thought that the two types of spermatozoa could be separated by an electric current, one type being attracted to the anode, the other to the cathode, but this has not been confirmed. So it is reasonable to conclude that as yet there is no procedure that will fix the sex of a child or modify it; nor does any method yet exist that will enable us to diagnose sex before birth.

The term parthenogenesis is applied to reproduction without the male; that is to say, to the development of an unfertilized egg. This is spontaneous and normal in a number of animals; in a number of others it is accidental or occurs under experimental conditions. It can be induced experimentally in some vertebrates—both amphibia and mammals. By a curious paradox of nature, parthenogenesis seems to occur more easily with the mammalian egg explanted *in vitro*. In this way, the beginning of development has been observed in different species of rodents (rabbit, mouse and rat). Complete gestation has been obtained with rabbit eggs subjected to abnormal temperatures *in vitro*, or treated with liquids that differ slightly from the natural physiological environment and then replaced in the uterus of a female (Pincus, 1939). If some young rabbits can be born following such treatment, could not the same result be obtained in human beings? Theoretically it is not impossible that a surgical operation of this kind could yield such a result. Without invoking moral and social arguments against such attempts being made (which would result only in females) at present they seem hardly practicable; what young woman, what wife, would submit herself to a complicated surgical operation for a problematical result?

Is it possible to produce twins at will? It is necessary to distinguish here between true or uniovular (identical) twins, produced from a single egg, and ordinary or dizogote (fraternal) twins produced from two eggs.

Mechanical or microsurgical procedures make it possible to produce two or several embryos from a single egg of amphibia, birds or even mammals. In mammals, it is necessary to remove the fertilized egg from the oviduct at the moment when it is undergoing the first cleavage and to operate on it *in vitro*, and then replace it in the maternal uterus. This has recently been done by Tarkowski. The same procedure is theoretically possible in human beings. Again, it is impractical at the moment; although it may have succeeded in a considerable number of cases with mice, most of the embryos thus treated either die or are monsters. Other procedures, such as the use of trypsin or saline solutions which contain neither calcium nor magnesium, have made it possible to induce in the eggs of amphibia the separation of the first blastomeres and the development of two or several embryos from isolated cells. Can one hope that these apparently less draconian techniques would give analogous results in mammals? In order to achieve such results it would be necessary to remove the eggs from their protective membrane and then implant them again in the uterus. This pre-supposes the same sort of surgical operations as those required for the mechanical procedures that have already been described.

It is also possible to cause the ovulation of several eggs by means of pituitary or placental gonadotrophic hormones. Injection of these hormones into female mammals causes the simultaneous ovulation of two or of several eggs in such species as ruminants, which usually ovulate only one. This procedure, which is used in some stock-breeding countries, could also be applied to human beings; but again, what woman would lightheartedly consent to bring into the world several children at the same time?

The culture of embryos and organs outside the body

What are the probabilities of Aldous Huxley's *Brave New World,* where human embryos are incubated *in vitro* from fertilization to birth and, during this artificial gestation, subjected by order of the authorities to various stimulating or retarding influences?

Let us dismiss the sensational 'facts' published by newspapers and weekly journals avid for novelty and scandal or disseminated by visual or sound media in every country, such as claims that human eggs fertilized *in vitro* had been reared in glass vessels, one of them to the twenty-five day stage, the other for a period of more than two months of foetal life. Such statements cannot be believed. No evidence of any kind, no valid documents, no scientific publication supports these claims. They may be considered premature, but it is not impossible that one day they will achieve reality. The results that have been obtained in this field by reliable scientists are as yet modest, but they do bear indications of new developments.

Such indications mostly concern the eggs or embryos of small mammals. As may be imagined, only a few experiments have dealt with the human egg and these have been possible only under exceptional circumstances, such as during the removal of healthy ovaries or the washing out of the Fallopian tubes during an operation performed for some other necessary purpose. The most remarkable result was obtained by Shettles (1955), who succeeded, after fertilizing a human egg *in* *vitro*, in making it develop over a period of seventy-two hours to the thirty-two cell stage in a medium composed of human follicular fluid. But we are still far from *Brave New World* and the test-tube baby. Experiments on animals (mice, rats and rabbits), however, have given more numerous and more promising results. For reasons that are still imperfectly understood, it is difficult to obtain continued development starting from undivided eggs; but fertilized eggs, removed during the early phases of cleavage (4–16 cells) can be cultivated for two or three days in media of known chemical constitution in which blood serum is replaced by albumin or amino acids. The development of these eggs, however, does not go beyond the 'blastocyst' stage, in which the embryo is composed of a large number of cells arranged round a cavity and already divided into an embryonic mass and a vesicle destined to form the accessory membranes of the foetus. No primary organ has been differentiated under these conditions.

The same does not hold if the blastocysts are removed after natural implantation in the uterus, and if they are cultured in plasma of the same species, primitive organs are then seen to differentiate *in vitro*: the dorsal notochord, somites, the nervous system, the digestive tube, and the heart. One of the most perfect results from such an operation was achieved in 1936 by Professor J. Jolly, of the Collège de France, who succeeded in extending the development of rat and guinea-pig embryos to the stage at which the heart showed rhythmic pulsations and pumped the blood in a complete and functional system of blood vessels. These *in vitro* developments, although corresponding to one of the most important phases of differentiation, last only for two or three days.

Thus numerous others have succeeded in cultivating embryos *in vitro* for certain periods of their development—in making them follow *in vitro* the normal development that occurs in the maternal body. Piecing together these fragments of evidence as far as it has been possible to do so, an equivalent of a maximum duration of five to seven days gestation appears to have been obtained. This is by no means negligible for a species with a short gestation period, such as the mouse, the rat, or the rabbit. However, this applies only to the initial phase of gestation, before the embryo has grown to any size and is abundantly nourished by the placenta.

Numerous technical improvements need to be made in methods of *in vitro* culture in order for a mammalian embryo to continue to develop outside the maternal body. Without emphasizing the difficulties of the problem, it is worth mentioning that two essential conditions are required: exact knowledge of the nutritional needs of the young embryo, and the invention of devices for asceptic perfusion adapted to very small organisms, on the model of the artificial heart-lung. The question is one of difficult techniques; it is not a theoretical impossibility and the first steps along this path encourage us to believe that further progress will eventually be made. If such procedures were to be applied to the human species, what advantages would this bring? Better nutrition of the foetus, the administration of stimulants to the physical and intellectual faculties, the precocious application of vaccines and sera, increased resistance to certain diseases, and acquisition of tolerance to cells of other individuals, which would solve for ever the problem of grafts.

It is not denied that living organs and tissues can be preserved in culture to acquire their form, being made to pass from the undifferentiated to the differentiated state. A simple small piece of connective tissue can differentiate in a few days into a cartilaginous tibia with a diaphysis and two epiphyses which are of perfectly normal shape. A rudiment of a genital gland passes from the undifferentiated to the differentiated state, having the form and structure of an ovary or a testis. Does this mean the body can be broken down into detached pieces from which it could subsequently be reconstituted? We have not yet got as far as this: the experimental biologist cannot reconstitute what he has dissociated.

But it is not impossible that organs or organized tissues of skin or bone, or even of more complex organs, can be maintained in culture and one day serve as grafts. Adult organisms tolerate embryonic tissues much better than adult tissues derived from another individual and experiments of this kind on man have already given encouraging results. This is the first step that has been taken towards solving the problem of the homograft (a graft between two individuals of the same species).[3] No doubt tissues cultured for a long time *in vitro*, and thus adapted to new conditions and to some extent 'despecified', would be better tolerated by the adult organism. Thus we should be on the way towards the establishment of tissue banks which would provide living pieces destined to become living grafts for use instead of temporary dressings.

The prevention of malformations

Many children are born deformed. The exact percentage of abnormal beings cannot be estimated because many monsters die before the end of gestation or before birth. Can the slight or serious malformations, which affect so many human beings, be avoided?

Some malformations are hereditary and their elimination, as we have seen, depends on eugenics. Others are due to accidents in development and are caused by factors outside the embryo. It is difficult, if not impossible, to establish the precise causes of them in each particular case—but numerous teratogenic factors are known, the effects of which can be forecast and are therefore avoidable. Such are numerous chemical substances and drugs which can be either toxic or harmless to adults: acids, alcohols, bases, alkaloids, sulphonamides and sterols. P. Ancel has listed numerous examples and has shown the specific effect of various drugs on chick embryos. Some cause achondroplasia, others polydactyly, harelip or cleft palate. The most remarkable and unhappy example of this teratogenic effect is provided by thalidomide, a tranquillizing substance, apparently harmless to pregnant women, which has caused the birth of thousands of monsters, afflicted by a malformation called *phocomelia*, which consists in a shortening of the limbs, the feet or hands being attached almost directly to the trunk.[4] Warkany and Giroud have demonstrated the teratogenic property of avitaminoses (peantothenic acid, folic acid) and excess of hypervitaminoses (vitamin A), the effects of which differ according to the stage at which they are taken (anencephaly, anophthalmia, harelip and cleft palate).

Other congenital malformations of the foetus are caused by diseases contracted by the mother during pregnancy. Fortunately the list of these is still short. German measles, a disease which is generally benign in adults, causes in the child very serious afflictions of the eyes, the heart and other organs when it occurs in the mother before the third month of pregnancy. There are other diseases too which can be regarded as responsible for serious lesions in the embryo, but the list of them is still not complete. It is probably necessary, however, to exclude syphilis, formerly regarded by many doctors as a common cause of malformations. Children who are infected before birth with the spirochaetes of syphilis are profoundly affected by the disease itself, not by its indirect consequences.

What recommendations, what rules of conduct can be deduced from our knowledge of teratogenic factors? Nothing very precise as yet, apart from some nutritional rules and general preventive measures, such as to avoid deficiencies or excesses of vitamins, unbalanced diets, and the use of certain drugs, the list of which will soon be extended when they have been tested methodically on animals or when unfortunate accidents have revealed their toxicity to human embryos. Doctors who recommend new drugs may be relieved of responsibility, for it should be added that some of these drugs, although quite harmless to the progeny of some experimental animals, can be dangerous to human

---

(3) *See the next chapter.*

(4) *B. Salzgeber recently obtained in my laboratory the same malformation in* 100 *per cent of cases, by injecting a bird embryo, at a certain stage of its development, with another highly toxic medicinal substance, nitrogen mustard.*

progeny. It is advisable, therefore, to be extremely cautious whenever new drugs are introduced into medical practice and to consider not only their effects on the present generation, but also their repercussions on future generations. Certain substances can be injurious not only to the embryo, but also to the male and female germinal cells and can cause permanent modifications in future descendants.

Other causes of malformations are radiations (X-rays, irradiation from radium or radioactive substances, ultraviolet radiation and ultrasonic waves). It is superfluous to emphasize the danger of atom-bomb radiation; it is advisable only to distinguish between the immediate effects of direct irradiation of the foetus and later effects due to definite modifications of the germ cells.

The experimental production of mutations

In addition to factors which cause developmental tragedies, there are those which determine mutations that modify the hereditary constitution of the germ cells, for these disturbing agents do not affect only the bodily or somatic structures of the individual; they can also influence the germ-plasm which is not sheltered from outside influences. These agents can be the same as those that cause malformations during embryonic development, such as short-wave radiations (X-rays, gamma rays of radium) and certain radiomimetic substances (mustard gas or antimitotic substances; colchichine). These modify the genes which bear the hereditary characters and usually cause harmful changes or teratological or lethal mutations. Massive doses of radiation, or light but repeated irradiation, would produce such modifications in man and cause deterioration. One can see in what a nefarious direction the human race would be modified if care were not taken to avoid it. Modifications in the number of chromosomes constitute a special category of mutations, the presence of a supplementary chromosome or the absence of one of the partners in one pair of chromosomes. These aberrations exist in man. It has recently been shown that they are responsible for serious defects, such as mongolism and certain forms of intersexuality. These chromosomal anomalies (called aneuploid) are harmful even if they include a supplementary chromosome, as happens in the case of mongols. These anomalies are due to an irregularity in the separation of the chromosomes of one pair, probably at the time of meiosis. But how are they produced? In mongolism the action on the gametes of

⁂

external factors which depend on the maternal environment, is certainly to blame, because the proportion of mongoloid children increases with the age of the mother and becomes very important (2·5%) among women of more than thirty-five years of age. It is to be hoped that future research will result in discovery of the factors causing mongolism and perhaps enable us to abolish this unhappy anomaly.

Can we produce beneficient mutations? 'Controlled' mutations have been produced in bacteria from the effect of deoxyribonucleic acid transferred from one strain to another, the characteristics of one being transmitted to the other. Would it not be possible to modify the racial characters of higher animals and man in the same way? Research involving the use of DNA and other substances has been undertaken in recent years on birds and mammals, but the results of these experiments are still controversial. So far, man possesses only the means of causing undesirable mutations. It is not impossible, though, that he may do better in the future, but the procedure which might revolutionize science and humanity has still to be discovered.

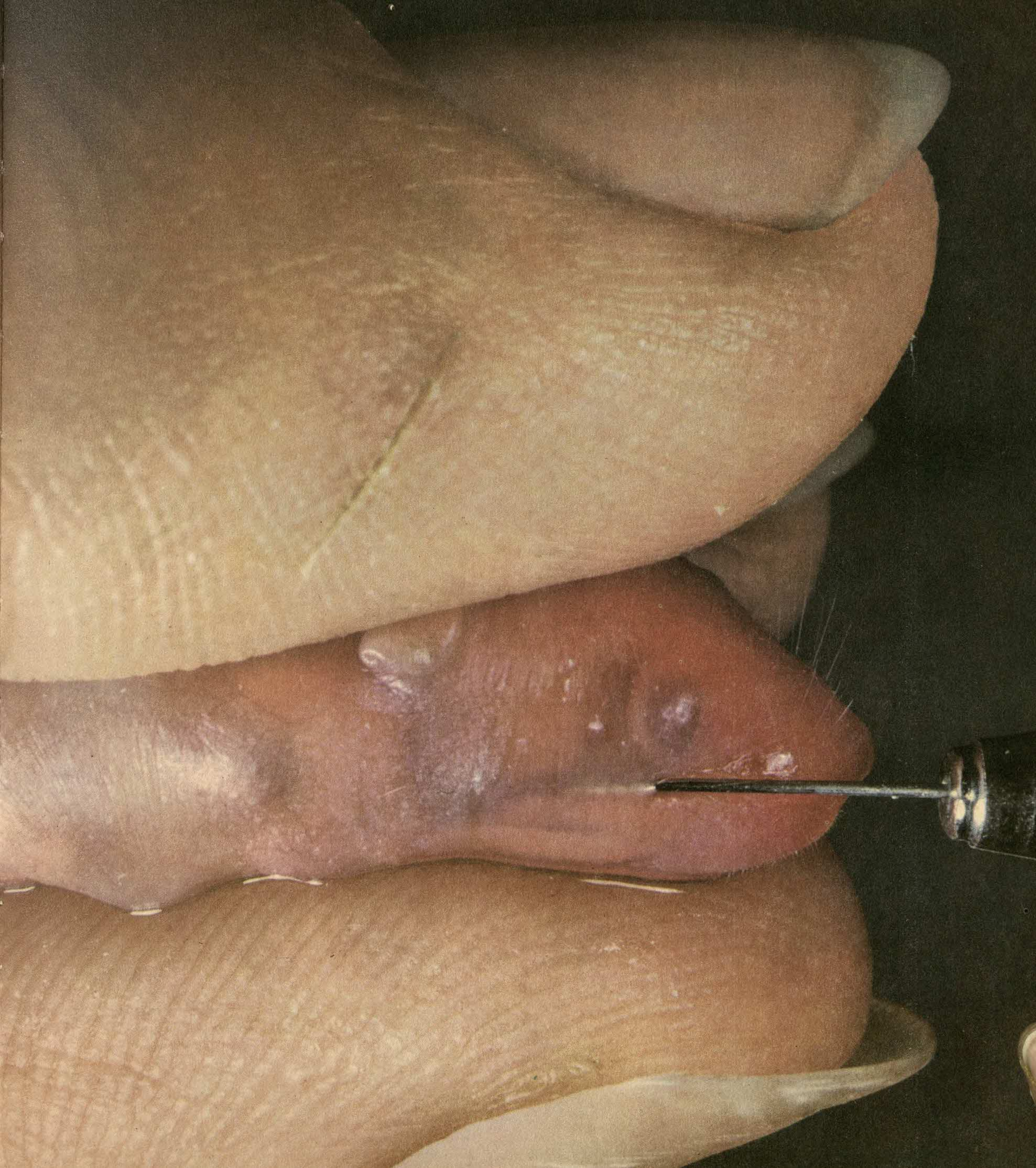
The results of experimental biology so far attained have placed at man's disposal certain methods of modifying his physical and mental constitution, of correcting errors of nature, and eliminating hereditary faults. Other possibilities cannot yet be realized, but they can be envisaged for the future. It is incumbent on us, therefore, to make our contemporaries aware both of the advantages and of the dangers of the methods which science has placed at our disposal.

Let us, in conclusion, cite a humorous forecast made by Jean Rostand, who depicts the anguish of 'homo biologicus', modified and sophisticated by varied and repeated treatments, most of which are still—and this must be emphasized—imaginary:

'I was born of stock chosen and irradiated by neutrons; they chose my sex and I was born of a mother who was not mine; during my development, I have been given injections of hormones and DNA; I have benefited from treatment which superactivated the cortex of my brain; after my birth, tissue grafts were made to improve my intellectual development, and even now I submit myself every year to a course of maintenance treatment in order to keep my mind in good shape and my instincts at an optimum level. I have no reason to be discontented with my body, my sex, or my life, but who am I?'

⁂

Albert Delaunay tells us that the question of grafting is one of the hardest and most emotional in medicine. It is to overcome the enormous difficulties of graft intolerance that experiments are carried out on animals, such as this experiment on a newborn mouse.



Tissue grafts

Albert DELAUNAY

The problem of grafts is one of the most difficult and exciting of modern medicine. No completely satisfactory solution has yet been found, but everything points to its being one of the main achievements of the not too distant future.

It may be useful to give a few definitions here in order to clarify the nature of the problem. The term *homograft* is used for the grafting of a fragment of tissue or of an organ removed from one individual (the donor) onto another individual (the receiver), both being of the same species. When the same individual is both donor and receiver, the term *autograft* is used; when they are of different species the term used is *heterograft. Transplantation* is the term used to define the graft of a whole organ (a kidney, for instance) and the re-establishment of the continuity of the vessels (and, if necessary, of the excretory ducts).

Autografts are almost always successful, but as a general rule homografts and heterografts are not. To take a simple case: a skin autograft and a skin homograft on a rabbit. At first, the two grafts react in the same way. On about the third day, a small vascular rash appears. The grafts, until then pale, begin to turn pink. On about the sixth day, the Malpighian epithelium in the area of the graft shows signs of intense mitotic activity, accompanied by slight desquamation.

Until the end of the first week, the appearance of the two grafts will have been more or less the same. Then suddenly a change occurs. Everything continues to go well with the autograft, which becomes more and more firmly attached to the surrounding skin. Soon it becomes an integral part of it. But the homograft tends to become bluish (cyanotic). The epithelium shows abundant desquamation and an oozing surface and brownish indurations appear here and there. Finally, the whole graft begins to show signs of necrosis, and on about the tenth or twelfth day it is eliminated.

This process has been known for a long time, yet it has always caused surprise. Why—with a few exceptions, and even they are debatable—is a homograft always rejected?

The theory of antibodies

Many theories have been advanced. One, known as the theory of *athrepsis* was originally put forward by P. Ehrlich, and has recently been taken up again, with some modifications, by Conway and his colleagues. According to this theory, the death of the homograft could be due to faulty vascularization. However, this does not seem very likely. What seems a good deal more probable is that the necrosis results from the nature of the grafted tissue, which does not die from simple inanition, but is actively rejected by the receiver.

Another theory—that of *local cellular reaction*—has been supported by J. Loeb and J. B. Murphy. According to this theory, the graft may become necrotic because it is gradually destroyed by lymphocytes attracted 'locally' by some 'differential' factors in the graft. But this hypothesis also no longer finds much support. According to a third theory, the necrosis of the graft could be due to a reaction provoked by contact with distinct *tissue groups* (comparable to blood groups). This may be so, but one strong objection to this theory is that there is no evidence that such groups exist.

What, then, is the cause of this phenomenon? The theory most in favour at present is that of *actively acquired immunity*, propounded by P. B. Medawar. This attributes the elimination of the grafted tissue to the intervention of antibodies[1] and many powerful arguments support the theory:

1. Experiments have shown that any factors that can increase the receiver's immunological reaction to the graft decreases the length of life of the graft. This is demonstrated very convincingly by what is called the *second set* phenomenon described by Medawar: a second graft from the same donor onto the same receiver dies more quickly than the first.

2. As a corollary to the above, there is another argument. All factors capable of decreasing the immunological reaction of the recipient can also increase the length of life of the graft. Two such factors of importance are at present known: irradiation by X-ray, and hormone therapy (ACTH and cortisone).

3. A recipient rejects a graft only when an immunological reaction occurs between it and the graft. At least two such cases are known: *(a)* when the receiver is not '*immunologically* competent'; that is to say, when it cannot manufacture antibodies; *(b)* when the graft fails to bring antigenic bodies with it; that is to say, the factors which normally stimulate the production of antibodies.

Thus homografts, and even heterografts, may be successfully performed on the embryos of chickens, mice, or rats; these embryos are '*immunologically incompetent*'. More—it is known that young tissues are, in general, more successfully grafted than others; and they are known to have a weak immunological competence.

Most scientists would be convinced by such an array of arguments, but a few still refuse to accept them. They say, for instance, that there have been some successful homografts; that in such cases there has been no evidence of antigraft antibodies in recipients, and that the development in them of hypersensitivity has not been conclusively proved. There is certainly an element of truth in both these arguments. But we must not go too far. The successful homografts—those of the cornea, arteries, or bone, for example, are not, in fact, living grafts, but 'dead' ones. Moreover, it is inaccurate to say that no evidence has been found of antigraft antibodies in the recipient. In some cases this is known to have occurred. In short, the rejection of homografts owing to the reaction of antigen[2] antibodies is a sufficiently well established fact.

What is a graft antigen?

What are these antigens? Recently, a French biologist, G. Voisin, questioned whether they might not have a connection with the *autoantigens*, substances which have the power of stimulating the animal which receives them (provided that it is *of the same species* as the donor) to manufacture antibodies. The question was pertinent, for a certain

(1) *A term used in its widest sense: serous or intracellular substances capable of reacting specifically with antigens which have caused their formation.*

(2) *Let us once more remember that an antigen is a substance capable of causing an organism to produce an antibody.*

Opposite page: These two photographs enable us to glimpse a solution of the formidable problem of the antigens of a graft; the mouse above has been given a graft without previous preparation. It is in the process of rejecting the graft, as is shown by the reddening around the area concerned. The mouse below has accepted the graft and after a year shows no sign of inability to tolerate it; it had been prepared by an intravenous injection of splenic cells taken from the stock to which the donor of the graft belonged, the injection having been given at birth by the technique illustrated in the photograph on page 33. (Photo Lod, taken in the laboratory of Dr Kimsky at the Hôpital Saint Antoine, Paris).

number of similarities have definitely been found to exist between graft antigens and autoantigens. For instance, in each case they were cellular or tissue antigens. Further, the corresponding antibodies are always cytotoxic. It is interesting to note that the three sites where homografts are best tolerated (the inner eye, the white matter of the nervous system, and the testicles) correspond to the tissues or the cells from which autoantigens (lens, white matter of the brain, and spermatozoa) can be extracted. However, upon further examination, certain dissimilarities have been brought to light, and these are more striking than the similarities. For instance, autoantigens are specific to the organs, whereas homograft antigens are specific to the individual. In contrast to this, the specificity of autoantigens is independent of the specificity of the individual. Finally, and not least significant, autoantigens manifest themselves as inert matter, whereas homograft antigens seem able to act only when they are present in the living cell which keeps intact the power of cytoplasmic synthesis.

From the nature of these dissimilarities, it appears that the study of autoantigens can hardly be of much use in the study of homograft antigens. What is the nature of these? The only thing about them that is certain is that they must be particularly unstable; that is to say, these antigens are weakened as soon as the cells that contain them are destroyed. Various components have been considered: deoxyribonucleic acids (Medawar), mucoids of the type found in blood-groups (Medawar), and ribonucleic substances. But as yet nothing can be considered as conclusive.

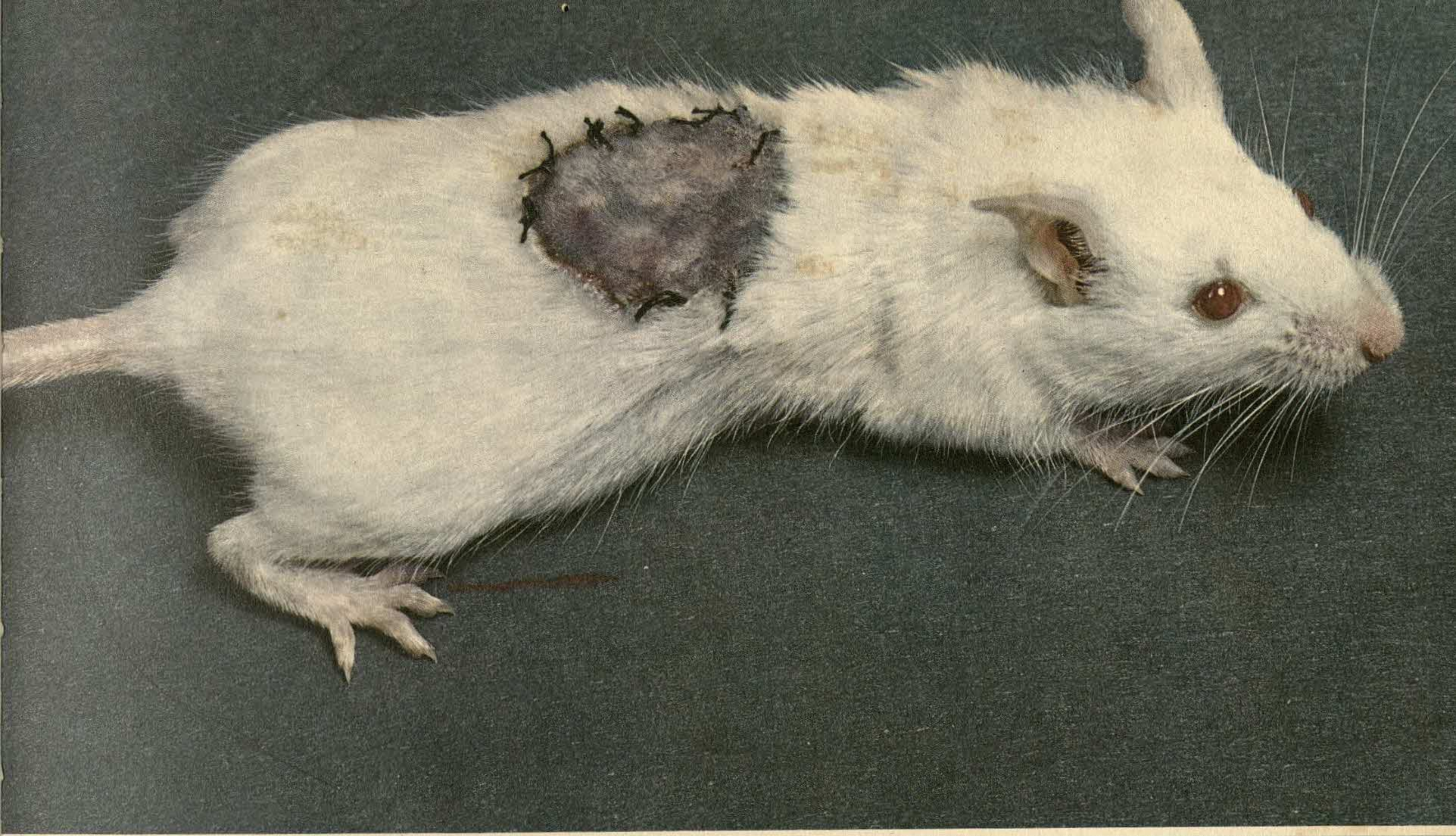
Actively acquired immunity

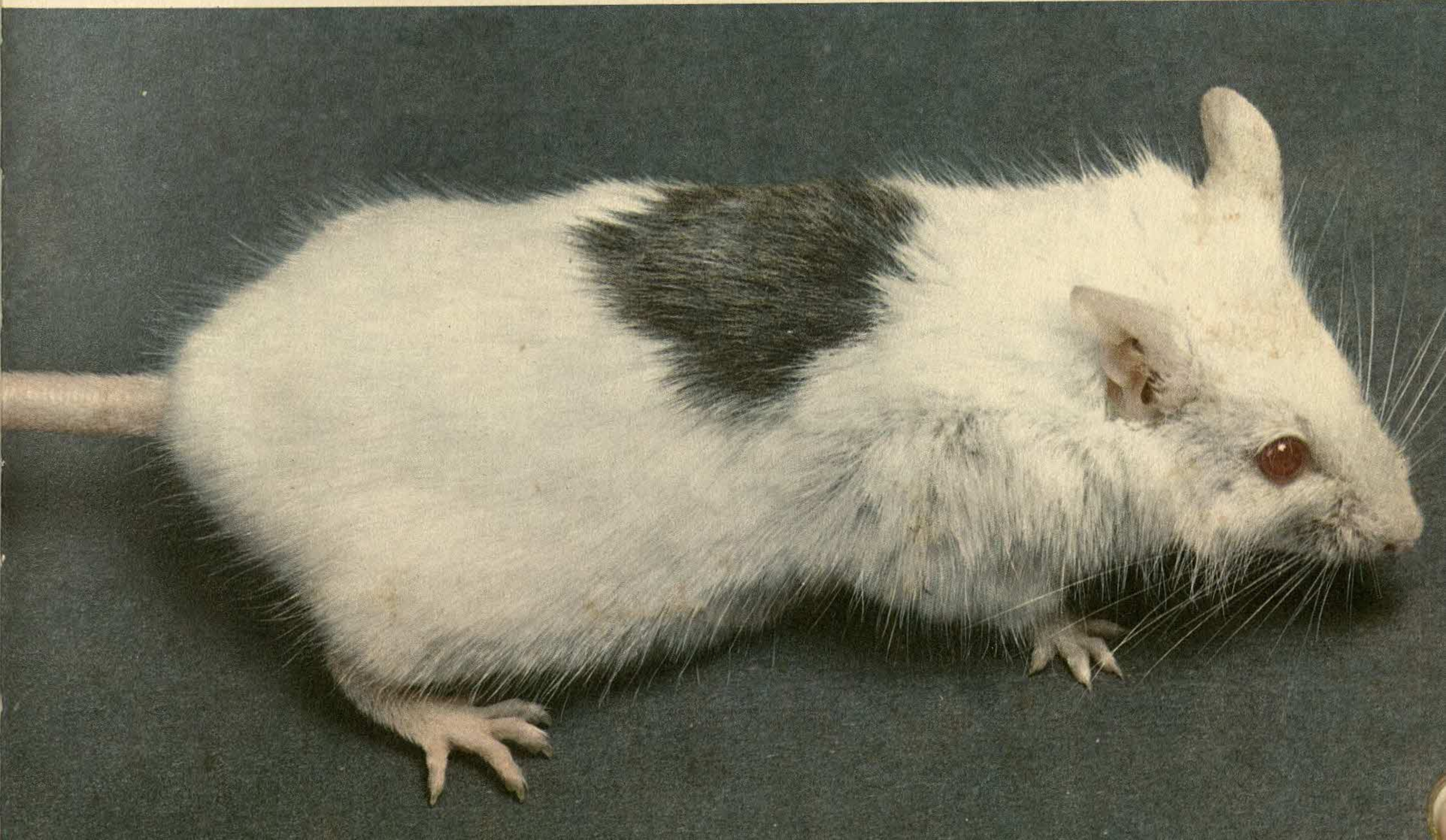
When we come to consider the corresponding antibodies, it is clear that our knowledge of these has not greatly increased either. In some cases it has been possible to demonstrate the presence of antibodies in a serum, but such cases are exceptional and they are accepted chiefly on indirect reasoning. Let us go back for a moment and reconsider two of the arguments put forward to justify the theory of *actively acquired immunity*.

The first of these arguments concerns the phenomenon of *the second set*, ie, when two skin grafts from the same donor are placed on the same receiver within a few days of each other, the second graft is eliminated more rapidly than the first (nine days and twelve days respectively). This fact points very clearly to there being an acquired sensitivity; from our present knowledge it would appear that such hypersensitivity cannot occur without the formation of antibodies. Having said this, it would seem useful to add that this phenomenon of the *second set*, discovered by Medawar and confirmed by several other scientists, has been reproduced by purely immunological methods. It was in this way that Voisin and Maurer were able to accelerate the rejection of a skin graft by operating on animals which had first been given subcutaneous injections of a solution composed of the powdered skin of the future donor mixed with adjuvant substances. (The latter, acting as irritants on tissue, are known to be capable of reinforcing the antigenic properties of a substance.) When sensitivity is sufficiently high, the phenomenon known as *white graft* may be seen (the graft is eliminated before the development of vascularization).

Furthermore, Voisin and Maurer were able to reproduce the phenomenon of the *second set* simply by injecting into the receiver the antiserum of a rabbit which had previously been injected with a cutaneous solution from the animal destined to be the future donor of the graft.

Let us consider now the second argument: that the life of a graft may be prolonged by non-specific desensitization, remembering that a desensitization of this kind can be obtained by radiation or by hormones. Indefinite graft survival has also been observed when the animal subjected to the graft has been *desensitized* during its embryonic life. In this instance, the procedure, discovered by the British scientists R. E. Billingham, L. Brent





and P. B. Medawar, was as follows: embryos of white mice, during their intra-uterine life, received blood cells from black mice. When the young white mice grew to be adults, skin grafts from black mice (these being black mice of a pure genetic stock, which allowed the graft to be taken from a mouse other than the one which originally gave the cells) were inserted into their cutaneous tissue. It was soon observed that the grafts of black skin survived. Obviously this could only have happened because the receiving animals were in a changed condition. Billingham, Brent and Medawar called this condition the *state of specific acquired tolerance.*

How is this state produced? The question is still debated, but many scientists believe that the phenomenon which causes it resembles, and may even be identical with the phenomenon of *specific inhibition* which has been observed by many immunologists. This phenomenon may be defined thus: the injection of a sufficient quantity of an antigen into an animal during its intra-uterine life (or even in its post-natal life) prevents it, when adult, from manufacturing the corresponding antibodies after another injection of the same antigen. The results of experiments undertaken by Billingham, Brent, and Medawar have already been substantiated many times and it has also been found possible to extend the experiment to birds and, recently, even to obtain at least a partial tolerance to heterografts (Hasek, Egdahl and Vasco).

The keen interest shown in the tissue grafts which have been here described very briefly arises from the hope that it will one day be easy for grafts and transplantations to be made on man. When we are quite sure of the cause of the present recurring failures, we shall, of course, be better equipped to overcome them.

The future of tissue grafting

It has been mentioned above that the rejection of homografts can be delayed in animals—and even in man—by careful use of hormones (ACTH, cortisone) or by radiation. To conclude, here are some further details of these radiations:

Attempts have been made during recent years to treat leukaemia by radiation. When radiations are applied in large doses, this is done with three objectives in view: (1) the

⁂

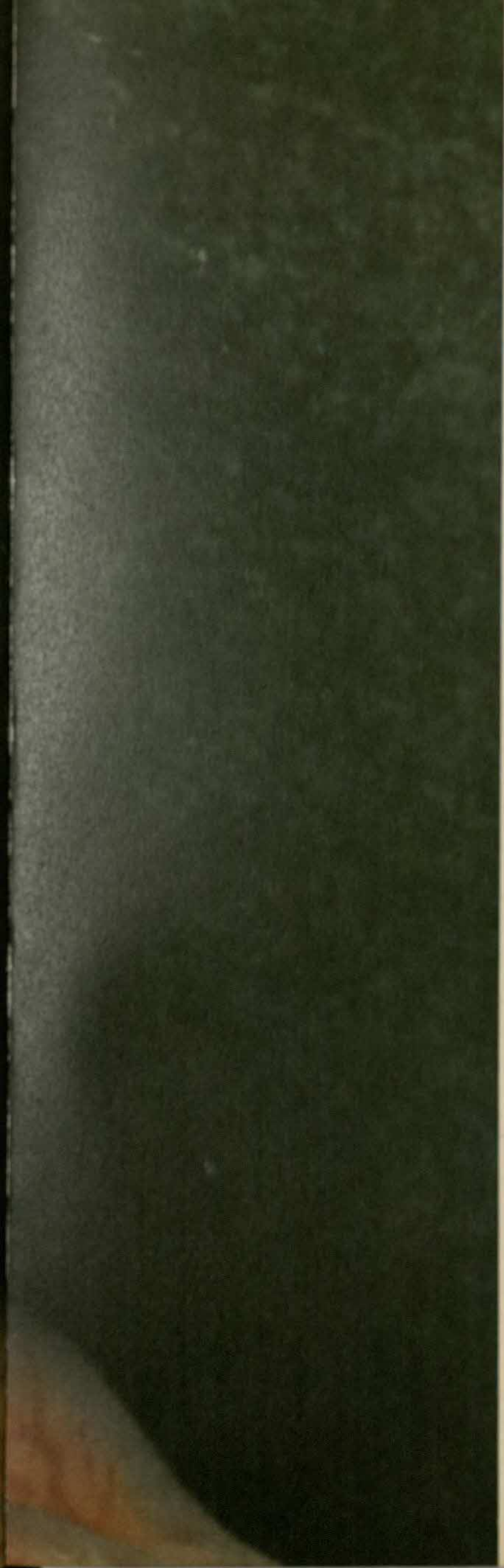
destruction of all leukaemic cells (ie, removal of the cause of the cancerous process); (2) the destruction of the cells which are '*immunologically competent*', that is to say, those which produce antibodies; (3) the facilitation, thanks to these cells having been destroyed, of the grafting of blood-forming tissues (preferably embryonic). The task of these tissues is chiefly to replace those already destroyed by the rays; in other words, to give the patient a new supply of active, healthy cells.

This would be a logical and magnificent programme, yet one that would be too good to be true, for it almost surpasses imagination. The recorded successes seem, in fact, to have been only partial. Moreover, it has never been definitely established that the reactions were produced in exactly the way that was anticipated. In spite of this, it must be admitted that the thing is possible, that we are succeeding in creating a type of chimerical man, for at least some of the cells which might help him to live would not really belong to him at all. Would this be for his ultimate good? We cannot say for certain.

Let us return for a moment to the phenomenon of specific tolerance which has been mentioned earlier, which permits cell-grafts to survive. This is surely a remarkable achievement. But over the years it has been realized that it presents certain disadvantages. It has been observed, for example, that 'chimerical' animals sometimes fall ill (Simonsen and Billingham); they cease to grow, become thin, and may even die. Billingham has called this new ailment abortive or *runt disease*. The cause is generally believed to be that the grafted cells reproduce themselves, and spread into the lymphatic nodes, colonize the centres of immunity, and there begin to react against the antigens of the host. Runt disease would result from the interaction of these antigens and antibodies manufactured by the grafted cells. The question has been asked whether similar phenomena might not occur in man, following a graft of living cells after irradiation. It is feared that this may be so. In fact, cases of this kind have been encountered in clinical practice.

Caution, therefore, is obviously necessary. Hopes may be disappointed. All the same, let us not forget all that biologists have taught us about grafts in less than fifteen years. The past is the pledge of the future, so it has been said. The clinical worker must continue to have faith in the laboratory, for it is from there that we shall receive the enlightenment for which we hope.

⁂



Behind the vascularization of the tissues which surround the brain of this human embryo, three months old, are already concealed the intellectual and psychological mechanisms, the mystery of which the neurophysiologists of tomorrow will try to pierce a little further. One of the strangest of these mysteries is that of memory, the faculty on which all thought depends, as Alexandre Monnier and Paul Laget tell us in the next chapter. Soon perhaps we shall understand its processes and origin. (Photo Lod).

The future of neurophysiology

Alexandre MONNIER and Paul LAGET

Predicting the future is more of a guessing game than a scientific exercise. On the other hand, predicting the future of a science can be a very reasonable though very speculative undertaking, and it is this double aspect that makes it so enjoyable. It encourages our hopes, and this is legitimate because they are based on present-day science, the rational basis of which can be tested by experiment at any time. Such speculation into the unknown is, in addition, a particularly fascinating field because it is thinking freed from the shackles of objectivity, subject only to the rules of sincerity and honesty.

Everyday science insists upon absolute objectivity. Conclusions drawn from experiments are based on observation of measuring instruments. These conclusions should only state the results of observation, though it is permissible to go further than this, provided that it is clearly stated that the scientist is advancing a hypothesis. Some do this boldly, among them modern theoretical physicists. Even their most extravagant hypotheses have always tempted experimenters. Often they have been proved right and, as a result, they have changed our generalized concepts of the universe. Certain basic principles, that is, certain patterns of thought which had been considered inviolable for thousands of years, have had to be revised completely. This has not been done without effort or regret, though it must be remembered that it has never been asserted that traditional patterns of thought are capable of sustaining the whole spectrum of reality. Reality presents so many varied aspects that different intellectual attitudes are not necessarily contradictory, but may in fact complement one another by representing different facets of reality.

Other scientists are less bold and flexible in their approach; they put forward hypotheses only with extreme caution. Among these are biologists and physiologists, and there is good reason for their hesitation. The phenomena which they study are extremely complex, depending on a great number of independently varying factors, many of which have still not been identified. Consequently, under apparently completely similar conditions, their instruments can give quite different results.

Thus contradictions can arise not only from successive experiments undertaken by the same research worker, but also from those of different scientists. This produces serious difficulties, because it tends to suppress any inclination towards the formulation of daring hypotheses.

In this chapter we shall abandon the traditional reserve of the physiologist to venture into the future of neurophysiology. Let us imagine that this future leads to a tremendously important discovery—the way in which memory works; that is, the discovery of the physiological mechanism of this very important faculty. We shall then try to envisage all the consequences that knowledge of this mechanism would have in regard to the whole field of human thought and activity.

Before starting, however, we must assess the importance of the undertaking and make an inventory of our resources, as well as indicate the approaches which have already been made from various angles towards the discovery of this distant objective.

The mechanism of memory

What do we know of the way in which memory works? Paradoxically, we know a great deal, and yet very little. Neurologists have carefully studied defects of memory, and have often been able to attribute the origin of these to definite lesions of certain nerve centres. They have made careful distinctions between the way in which memories are acquired and the way in which they are preserved. It is the ability to acquire memories which is most vulnerable to the onset of old age and illness, whereas once a memory has been fixed in the mind, it tends to persist throughout life, even when the ability to acquire new memories has failed. Thus old people love to recall their youth, the memory of which remains vividly with them; memories which are still fresh and living, although the photographs which record those long-past events have become faded and worn with the passing of time. These old memories are deeply engrained. They are impervious to the effects of complete deep anaesthesia, to severe wounds entailing excision of important nerve centres, to long drawn-out comas and to artificial hibernation which cools the body for many hours. They are also resistant to shocks of all kinds. The two world wars, which mutilated so many people, left surprisingly few cases of amnesia.

There is one important distinction between the cells—or neurones—of the nervous system and those of other parts of the body. The cells of the skin, for example, can reproduce themselves so as to replace the cells worn out or destroyed by a lesion or by use. This is the phenomenon of physiological regeneration or 'identical' reconstitution. On the other hand, the cells of the nerve centres cannot reproduce themselves. No fresh neurone is capable of healing over a possible future lesion. Other cells originating in connective tissue, the neuroglial cells, fill in the gap left by destroyed neurones, but they cannot be described as true nerve cells. Thus from birth to death our bodies contain a fixed number of these neurones which cannot be increased. However, as they are very numerous (our cerebral cortex contains several thousand million neurones) we are fortunately provided with a surplus which enables us to sustain severe cerebral lesions without harm, as well as allowing us to go on acquiring new memories. It is this permanence of the nerve cells throughout life which is probably the reason for the persistence of memories.

The recent and beneficent art of neurosurgery has made it possible to locate the boundaries of those regions of the brain where memories are built up and where they are stored. For example, Penfield has shown that slight excitation of certain zones of the temporal lobes immediately produces conscious and vivid recollection of old memories apparently long since forgotten.

Psychologists too have made a clear distinction between the way in which memory is acquired and the way in which it is preserved. In fact, what they have studied are the modalities of learning and of its retention. Using tests that are often extremely ingenious, they have been able to assess very accurately the way in which little by little an animal is trained or 'conditioned', a somewhat barbarous term, but in general use. There are also tests which can be used to assess man's ability to acquire and retain knowledge, and it is possible to estimate the influence of such factors as awareness and fatigue upon this ability.

Comparative psychology has made a fundamental contribution to the study of instinct, that is, innate knowledge or inherited behaviour. When insects emerge from the larval stage, they 'know' at once how to perform intricate actions without apparently ever having been taught anything. Their training seems to have been gradually built up within the germinal cells over innumerable generations. This would be equivalent to acceptance of the view that acquired characters are inherited, a hypothesis which has so far not been proved. Is it possible that insects possess an extremely pronounced ability to acquire knowledge—a kind of instant apprenticeship? This theory should not be rejected *a priori*, because it is thus that Pieron and Viaud have explained, for example, the return of migratory birds: by an instantly acquired memory of the places over which they have flown.

During the last thirty years, physiologists, using amplifiers and electronic oscillographs, have been able to identify the extremely minute but measurable signs of nervous activity. Each nerve, whether neurone or fibre, shows its activity by means of a clearly defined electrical signal. Thus it has been possible to observe the way in which sensory nerves pass impulses to the nerve centres. The motor impulses that are sent along nerves to the muscles can also be analyzed. In the same way, some of the activities of the centres may be shown. These electronic methods of observation have also shown functional links between the various centres that are not anatomically evident. For example, the electroencephalogram sometimes indicates a 'conditioning', in that it shows a new pattern produced by the experimenter: the path of a conditioned reflex. But this cannot in any way be regarded as the electrophysiological pattern of a memory, because a conditioned reflex is always unconscious. If it enters the consciousness of the individual it is only after it has occurred.

What conclusions can be drawn from these facts? Of the mechanism of memory we have circumstantial knowledge. We know with some precision the place where memories are built up in the brain; we also know, although in a much less certain manner, the vast regions where they are stored. We know how in the course of time the most varied skills are developed. We can understand, by its electrical manifestations, the activity of most of the components of the nervous system. But the mechanism of memory has up to now eluded the most sensitive electronic measurements. This is because that electrical nerve activity, which can be temporarily suppressed without harm under the effect of anaesthesia or coma, is perhaps in no way linked with the preservation of memories.

Many bold hypotheses have been put forward; some of them are very rigorous theoretical speculations. They may be divided into two categories, according to whether they are based on structural modalities or on formal analogy.

Arguments in favour of the structural theories are based upon discoveries made in the field of genetics. It is known that deoxyribonucleic acid (DNA), the chief constituent of the chromosome genes, appears to be the biochemical vector of heredity. The spiral-chain structure of these polymers can show an infinite number of variations; these variations are characterized by the order in which a number of chemical groups follow each other and repeat themselves throughout the chain. In addition, this acid, in all its variations, is capable of synthesizing, by contact, a protein which replicates it.

Hyden, and later Schmidt, recently put forward the view that ribonucleic acid (RNA), present in very high concentration in the neurones, and similar in structure to DNA, may be subject to similar variations. The repeated passage of a nerve impulse across a synapse, on this view, would gradually modify the sequence of the chemical groups attached to the ribonucleic acid chain. The distance between the groups would be governed by the rhythm of the nerve impulses. In this way a definite rhythm would 'engrave' a characteristic 'pattern' upon the synapse, thus leaving an increasingly facilitated passage for future nerve impulses corresponding exactly to this rhythm: that would be memory itself.

Hypotheses based on principles of analogy are derived from the functioning of electronic computers. Somewhat prematurely, these are often called 'artificial brains'. In fact, they are, like nerve centres, made up of many components. Generally, these are miniature circuits, the electronic state of which can only take two values, thereby allowing them to work on a binary system of numeration. These, then, are the very imperfect 'analogues' of the nerve components, but solely because these also can only be in two electronic states: either they are or they are not the seat of an electric wave; that is, the seat of a nerve impulse. However, when limited to such systems, electronic computers can only perform elementary operations, although they can do these amazingly quickly. The solution of complex problems requires equipment to define the programme for the machine's operations and to retain the results of these operations as they are carried out—this is what has been spoken of as systems possessed of memory. More exactly, these are varied systems, often magnetic, showing residual magnetism or hysteresis. Thus the analogy with the nervous system becomes so distant that it is no more than formal. For this reason several scientists, in particular Rosenblith, have deliberately abandoned any material analogy and have turned to purely symbolic representations. Such is the recent theory of 'perceptrons'. These have been defined as a network of varying units possessed of functions similar to those of the nerve components (sensory, associative, and responsive functions). These units are supposedly linked to an interacting 'matrix' which would be dependant upon the result of the states of activity of the network. Given this, matrix calculations would allow scientists to forecast the behaviour of the network in various circumstances. In particular, it would be possible to assess the probability of a definite situation arising within the network and the degree to which such a situation would persist.

This attempted explanation, with its extremely varied and often unexpected deductions, is perhaps a theoretical representation of the principal functions of the nerve centres. It may also be a theory of memory. But to what kind of nervous structure do such premises, in particular that of the interacting 'matrix' correspond? It will be a long time before this question is answered.

Speculative possibilities

Let us imagine that in a few years from now the mechanism of memory will be known. More explicitly, let us assume that the engraving of memories occurs because of a permanent change in certain contacts or interneuronal synapses, a change of a physicochemical nature which will have been clearly identified. Once this has happened, certain age-old problems will perhaps be solved, even if only in part. For instance, one is the problem of consciousness, which some contemporary psychologists have relegated so disdainfully to the philosophers. Another such problem will be that of thought structure, or at least that of logic; it may be that this structure has its origin in the biochemical nature of interneuronal contacts. Thus the scientific basis of philosophy might be established. We may even be able to use biochemical or pharmacodynamic means to improve memory or intellectual ability.

It would be possible to go on indefinitely in this way. None of the immense fund of knowledge accumulated through the ages is acquired without effort. Nevertheless, humanity has learned to store its knowledge carefully, first in oral tradition, later in inscriptions, and finally in books and libraries. However, in order to put this precious store to use, every man and woman must learn: learn to listen, to read, and finally to grasp and generalize the meaning contained in these words and letters.

If we could eliminate part of this effort which every human being has to make, that is, if we could introduce the fundamental basis of knowledge into our genes, this would mean that acquired characters could be inherited. Doubtless this is complete fantasy. But it might perhaps be possible to include in our heritage, if not knowledge, then more simply the ability to acquire it. Within a few generations there would follow an enormous increase in our knowledge, wholly because of a greater rapidity in the acquisition of memories.

This power will surely be refused us, for with it we should be like gods, and perhaps would be tempted to put it to bad use. It is also possible that inherited knowledge, or even too swift and too perfect a memory, would prevent all further progress of our species.

As far as insects are concerned, evolution seems to have slowed down. These animals, which can do everything without apparently having learned anything, have hardly evolved at all for long geological periods. On the other hand, it is possible that the future will show that the effort which each one of us makes to learn is the reason why intelligence and personality persist in the human species. This would explain the traditional wisdom of the religious precept whereby 'Each man's salvation is to be found through his own efforts'.

Nerve-cell differentiation

The problems presented by the mechanism of memory, the uncertainty of our hypotheses, and the haziness of our knowledge place us in immediate touch with the difficulties encountered when, passing from the study of the immediate or instantaneous phenomena located in the nervous system, we try to understand its functioning from an evolutionary point of view. The retention of memories, as we have seen, seems to imply a progressive and lasting change in neuronal elements. Another type of phenomenon can be compared with this, and that is nerve differentiation, which in man is far from being achieved at birth, and takes place over a long period afterwards.

We come into the world with a definite stock and an apparently definitive number of nerve cells, but it is out of the question to think that they, their functions and interrelations, are the same at birth as they are in adult life. During a child's early years, a tremendous amount of neurophysiological and also neurochemical differentiation takes place which continues and completes embryonic and foetal development. The new and frightening world that presents itself to the eyes of a baby is quite different from our world, not only because all the impressions and sensations which impinge on its senses and are recorded in its nervous system are new and surprising to it, but also because the receptors receiving these impressions, the means by which they are transmitted, and the centres which receive, combine and integrate them, are far from having acquired their final properties and functional structure.

For many years, child psychologists have studied the gradual development of perception, emotion and awareness: in other words, they have studied personality. These studies have provided very interesting data. In the case of experimental neurophysiology, matters are quite different. Here specialists are habitually working on adult animals that are easier to handle, less delicate, and the properties of whose nervous system are structurally fixed. Very few specialists are interested in the progressive development and growth of these properties.

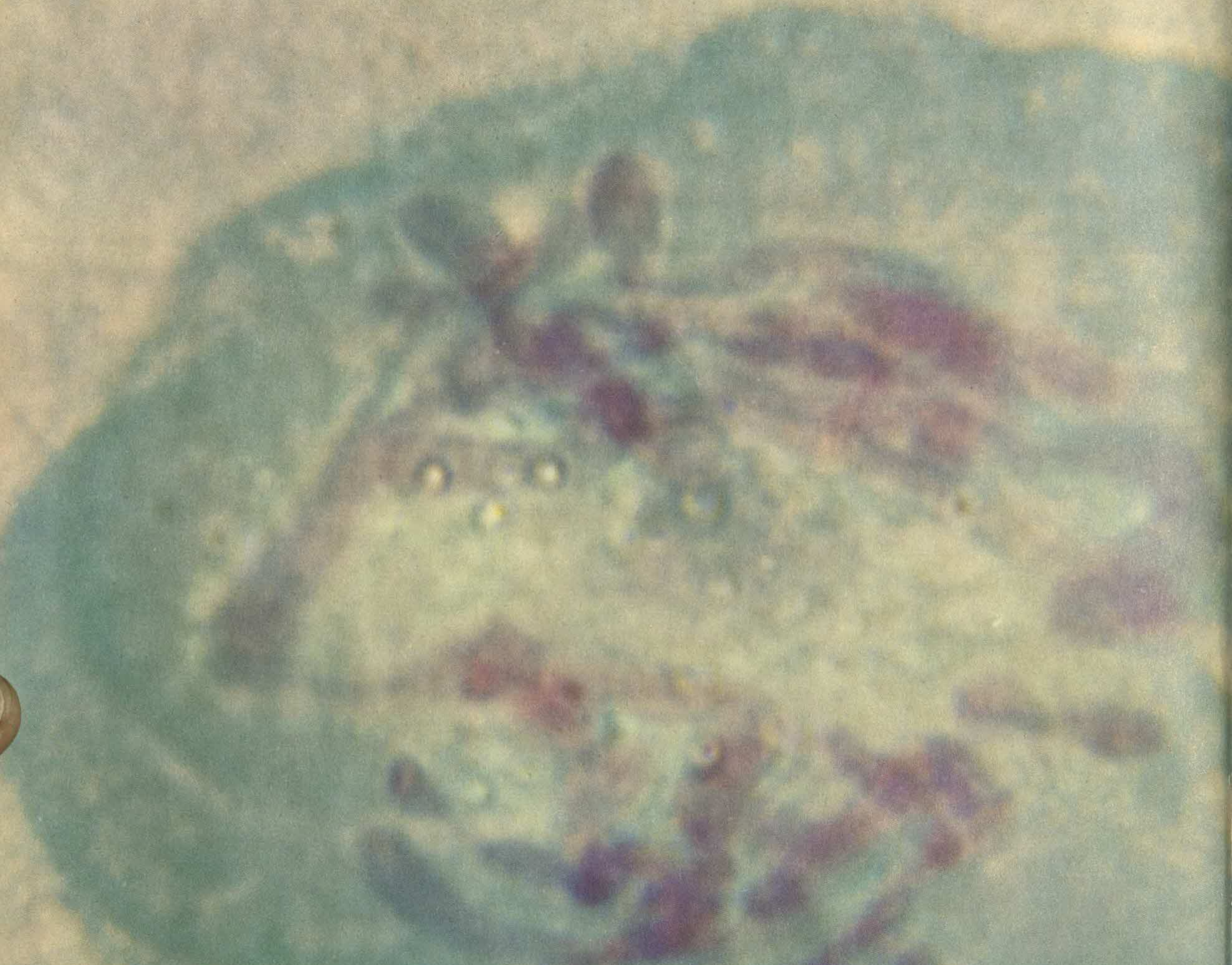
Nevertheless, results already achieved and more detailed techniques should enable neurophysiologists to tackle these problems. It is to be hoped that our knowledge of pre-natal and post-natal development of nerve functions and of the gradual building up of neurone circuits will be greatly increased in the near future.

The data derived from studies in neuro-embryology have provided a fairly solid structural basis; certain signs of electrophysiological function of the nervous system in man and adult animals have been carefully assessed, described and in some cases interpreted; we may now envisage the study of structure-function relations as they progressively develop and mature.

A certain amount of experimental research has already been carried out and some results have been obtained. It has been possible to describe fairly accurately the development of cortical electrical activity in man and in some laboratory animals from birth to adult life. In the case of the animals, signs of electrical activity in the sensory cortical areas when a visual, auditory, or tactile message reaches them have also been described. Important changes in medullary function that occur during growth and bring about the origin of the possibility of definite movement (walking, in the case of man), or the changeover from one method of movement to another (from walking to jumping, in certain mammals such as the rabbit), have now begun to be examined with modern neurophysiological techniques. In particular, the progress made with these techniques, which allows us to trace very faint cerebral electrical phenomena on the surface of the skull, will also make possible the functional study of the differentiation of the sensory and motor pathways and of the sensory cortical areas in babies and children.

When our knowledge of the different stages of post-natal nerve development will have acquired sufficient breadth and precision, another chapter may begin, in which explanation will supercede description. It will then be for the neurophysiologist and neurochemist to seek the hidden mechanisms of this development, and to try to understand the chain of causes that are concerned with the elaboration of functional properties. Experimenters will then have fascinating possibilities and an open field in which to use their imagination and ingenuity.

There is more. According as our understanding is extended, infinitely beneficial possibilities of action may emerge. At present, there is no field of human neuropathology in which we are more helpless than in that of malformations and delays in development of the nervous system. Some of these are due to defects in our genetic inheritance and for this we cannot yet envisage any treatment; but for others which are due to a pathological cause perhaps already suspected or even known, there is hope that the progress in our knowledge of the mechanisms of neurophysiological differentiation will express itself in the acquisition of means to prevent or even to correct or to cure lesions that at present are irremediable.



This photograph shows paramecia pairing. Creatures such as these, which have evolved very little, are nevertheless endowed with potential immortality—that eternal dream of man. When and how will it be made possible for multicellular organisms to become adapted to this faculty? As Professor Binet explains in the following chapter, the span of human life has already been considerably extended. (Photo Lod).

The prolongation of life

Léon BINET

The prolongation of human life is a dream that has always obsessed humanity. According to the geometrician, Maupertuis, it, together with the philosophers' stone, the squaring of the circle, and perpetual movement, has been one of those dreams which in every age 'flatter and torment the intellect'.

Up to a point, this dream has come true: the span of human life in 1965 is much longer, on the average, than it was at the beginning of the century; this is one of the great triumphs of scientific research and is a portent to anyone who tends to underestimate the benefits of science.

What is the cause of this prolongation of life, so clearly indicated by statistics? Obviously, it is due to the progress of medicine, surgery, and hygiene, which have caused certain diseases to disappear, made some more rare, and lessened the seriousness of others. It is also due to the progress of social legislation which enables more and more people to benefit from the application of knowledge.

In this chapter, Léon Binet, Dean of the Faculty of Medicine of Paris, outlines the present position concerning longevity and discusses the possibility of improving the physical condition of old people.

Jean Rostand

Biologists, doctors, and sociologists are keenly interested in the problem of human longevity and the prolongation of life. All statistics show that today life is much longer than it was in the past. Confirmation of this can be seen by studying the longevity of the inhabitants of Paris.

The average age of death in Paris rose progressively from forty years in 1900 to fifty-seven years in 1950, which represents an average gain of seventeen years in half a century. In relation to the total number of deaths registered in Paris from 1900 to 1950, the percentage of deaths of people over sixty rose considerably, and the percentage of deaths in the 0 to 19 age group (babies, infants, and adolescents) diminished markedly. In 1900, the percentage of deaths from 0 to 19 years was nearly 26 per cent, but that of people over sixty-five was only 22·5 per cent of the total number of deaths. In 1950, when 50 per cent of Parisians who died were over sixty-five (as against 22·5 per cent in 1900), the proportion of deaths in young people (from 0 to 19) fell to 9 per cent (having been 26 per cent in 1900).

In 1900, 58 per cent of Parisians died before the age of fifty; 19·5 per cent between fifty and sixty-five; 22·5 per cent after the age of sixty-five. In 1950, 24 per cent of Parisians died before the age of fifty; 26 per cent between fifty and sixty-five years; and 50 per cent after the age of sixty-five.

It is possible to discern the factors in this increase of longevity which—and this must be emphasized—are accompanied by a marked retardation in the appearance of signs of senescence. People live longer and 'age' later than they used to[1] because man now understands himself better and knows better how to protect himself.

To sum up we should bear two remarkable statistics in mind:

The average age of death in Paris rose from forty in 1900 to fifty-seven in 1950, representing an average gain of seventeen years in half a century.

Again, in 1900, for every 20,000 annual deaths in Paris, there were 947 people aged eighty years or more; in 1950, for 20,000 annual deaths, there were 2,957 octogenarians. These statistics force us to conclude that we live longer than our fathers and to hope that the length of our lives will increase more and more.

The statistics show, incidentally, that longevity is markedly greater in women than in men.

The lengthening of human life is indisputable, although it is more difficult to define the 'value' of a man whose existence is prolonged. Using the information that we have collected, let us examine muscular effort, the condition of respiration and of the blood, endocrine glands, and eyesight, with regard to the effects of age on the organism.

Human longevity

Muscle is the first tissue affected by senescence. Fatigue is an early sign of approaching of age. Muscular involution occurs. This is to be seen in the effects on one's ability to work and the amount of effort required in walking. But in order to steer a boat it is not necessary to be able to climb the mast, as the ancients used to say.

Vital capacity is the maximum amount of air that can be breathed out completely after deep inspiration. Normally, it is 3·5 litres. With age, a progressive decrease occurs in the value of vital capacity. The difference observed between one person and another is very marked. We have found an upper limit of about 2,200 cc and a lower limit of about 900 cc.

The tidal volume (or respiratory output at rest) is the quantity of air breathed in or out during each respiratory cycle. The average value is normally about 500 cc. In old people we find an approximately constant value of about 370 cc. It has thus diminished by about 25 per cent as compared with the average. Of all the component aspects of respiratory function, this is the least affected and the most stable, the extremes of variation being slight.

Basic metabolism is the minimum value

(1) *Nevertheless, we must not forget the significance of different ways of living. There is a considerable difference between manual workers' expectation of life and that of professional and technical workers.*

W.O.

Men		*Women*	
Age 72	29	Age 70	25.5
76	26	74	28.5
78	24.5	78	23
93	23	94	24.5

Women *Men*		*Women*	
	1,600		1,400
Age 72	980	Age 70	860
76	940	74	910
78	955	81	960
93	960	85	845
		94	760

(This table contains the latest figures given by L. Binet, Mlle M. Bochet and Mme J. Vallery-Masson)

sufficient to maintain life without external effort under certain defined conditions. It is expressed in calories per hour per unit of body surface. Basic output corresponds to the number of calories, in absolute value, that would be released by the organism at rest in twenty-four hours under the same conditions. It is very small at birth, when basic metabolism is about twenty-five calories, rises very rapidly in the first months, and then settles down to a value of fifty to sixty calories towards the fifth year, after which it declines imperceptibly. In the adult, the figures are: basic metabolism 38·5 $cal/m^2/h$ and basic output 1,800 cal/d for men; and 36·5 and 1,400 respectively for women between thirty and forty years of age.

Basal metabolism in men of thirty-five is 39·5 $cal/m^2/h$, and in men of seventy-five 32·5; in women it is 36·5 at thirty-five, and 33 at seventy-five. Among people of advanced age, we have found many figures lower than these, which may be taken to represent an average.

Muscular strength and breathing

Respiratory tests are of considerable practical interest because they give the doctor information about the nutrition of old people and indications of the treatment which they need.

Blood, hormones, vision, hearing, and psychomotor condition

The diminution of cardiac flow and of glomerular filtration of the kidney is well established. It is often the practice to estimate cholesterol in an old person, although this measurement is no longer as important as it seemed a few years ago, because many elderly people have a normal cholesterol level.

Some doctors stress the importance of counting the eosinophil white blood cells, because people who are ageing show a decrease in eosinophil cells, which is all the greater as senescence becomes more marked.

Glands of internal secretion are clearly affected by age, and the genital glands undergo involution. It is current practice to estimate 17-keto steroids, which diminish in old people. Specialists are concerned also with the careful study of the eyes; failures of accommodation are of great importance. Power of accommodation decreases with age, and it is common knowledge that hearing is also often affected.

Psychologists and physiologists have also studied senescence in relation to psycho-motor reaction-times, and these are of great interest. Investigations show that all individuals do not age in the same way, nor all the organs of the body at the same rate. Moreover, there are people who, though advanced in years, are still young so far as their physiological condition is concerned. With the poet, we may say that youth is handsome, but old age magnificent.

How to live longer

In order to 'live longer and better' it is necessary in some cases to use powerful methods of treatment. Noticeable results may sometimes be observed from the action of male sex hormones (administered by various routes) and of certain injectable embryo extracts; also from vitamin treatment, either using single vitamins or administering them in multiple form, and from various mixed substances, especially those containing methyl-phosphate of magnesium, calcium gluconate and methionine. For a long time, albumin iodates have been used in association with sodium citrate and oxygen treatment, and pure procaine or its derivatives must also be mentioned.

Besides these methods, which come strictly within the province of the doctor and which a layman cannot prescribe for himself, attention must be drawn to certain other factors of secondary importance, among which dietary considerations would appear to us to be of special interest to anyone wishing to prolong his life. It may be thought that this is a minor detail, but there are small as well as large weapons that can be usefully employed in the face of old age and death. We shall describe here the ideal diet for an ageing person.

Even in the absence of any serious disease, appetite and digestion are often disturbed in old people. Mastication is frequently insufficient, so foods are required that are easy to chew and can be given as a purée or a soup. The diet must supply at least 1,800 or 2,000 calories per day and must be balanced in proteins, carbohydrates and fats; it must also include vitamins A, B, and C, and mineral salts.

The diet may be divided into three, or even better, four meals; breakfast, lunch, tea and dinner; this allows for better assimilation and avoids hypoglycaemia being caused by too long a fast between important meals.

Nutrition should be checked by monthly weighing, so as to avoid any over-feeding, or to detect any difficulty in assimilation.

The sources of youth

The question of mineral water cures for old people has also been studied. I have before me a detailed report made by my colleagues Robert Cuvelier, of Clermont-Ferrand, and Michel Fontan, of Lille, which deals with the uses of hydrotherapy and climatotherapy in the prevention of old age. In this report, which was read as a paper at the National Scientific Symposium at Evian in 1961, the authors conclude, with Montaigne, that spa treatments, 'if they cannot restore a ruin, may at least prevent further deterioration'.

Decorating the walls of the new Faculty of Medicine at Paris, there is a plaque of water-nymphs, depicting the therapeutic value of mineral waters for children. But why not a similar plaque showing their identical effect on old people?

We are often asked the question, to which spa should I go for a cure? To this there is no general answer. At Aix-les-Bains and at Chatel-Guyon, with its waters rich in magnesium, attempts are made to prevent the disturbances common to old age. Thermal sulphur spas proclaim their ability to reduce tracheo-bronchial catarrh, so frequent in old people, and to stimulate appetite. Near Paris, the waters may be taken at Enghien-les-Bains. Vichy quotes with pride Cardinal Richelieu who frequented it 'to try to overcome his decrepitude'. A few years ago, Vittel organized a Congress of Longevity. We recommend Evian because its climate is so soothing, restoring sleep to sufferers from insomnia, while its diuretic waters have an established power of detoxication, and relaxation on the shore of the lake has a remarkable effect on the nerves of certain elderly people. One thing more: the necessity for *intellectual* stimulation should be emphasized. An old person must keep his mental faculties alert. He must use his brain, for inactivity of the mind is a serious danger. 'Retirement and pensioning off is abdication, it is certain senility', wrote L. Brull, quite rightly; and General Douglas MacArthur gave this advice: 'You'll stay young if you remain receptive, receptive to that which is beautiful, good and true.'

The future of gerontology

We have seen to what extent gerontology today may help with the prolongation of life, and it is possible that future medical discoveries and new social adjustments will add still further to this prolongation. But how far will it be possible to progress? No precise answer can be given to this question because we do not yet know what part is played in the process of organic deterioration by certain morbid factors and accidental causes. Everything suggests that as a result of the elimination or gradual reduction of these causes most human beings will quite possibly reach a very advanced age—the so-called age of natural death—which, according to Metchnikoff, and, as I myself believe, should be about one hundred years. This would be a considerable advantage because it would deprive death of the dramatic character that it too often has today. In a man who reached this age, it is thought that a kind of instinct—a death instinct—would assert itself, analagous to the need for sleep which we experience at the end of a full day's work.

However, this reasonable prospect does not entirely satisfy the biologist. Gradually to abolish all extrinsic causes of accident or death would allow natural ageing to occur normally and simply but in itself would hardly be enough to satisfy the ambitions of the biologist. Through active intervention, he hopes to counterbalance the process of senescence and to combat its deep and intrinsic causes.

He pretends to fight not only against accident, but against nature herself, so as to extend the limits of longevity of our species. This idea is linked with the age-old wish of humanity, the 'loom of youth' or the Faustian myth.

It is almost certain that biology will eventually succeed in some aspects of this difficult enterprise. There seems to be no *a priori* reason why the phenomenon of senility should defy the efforts of an experimental discipline for ever, for the successes of biology are innumerable and it has already learnt to

⁂

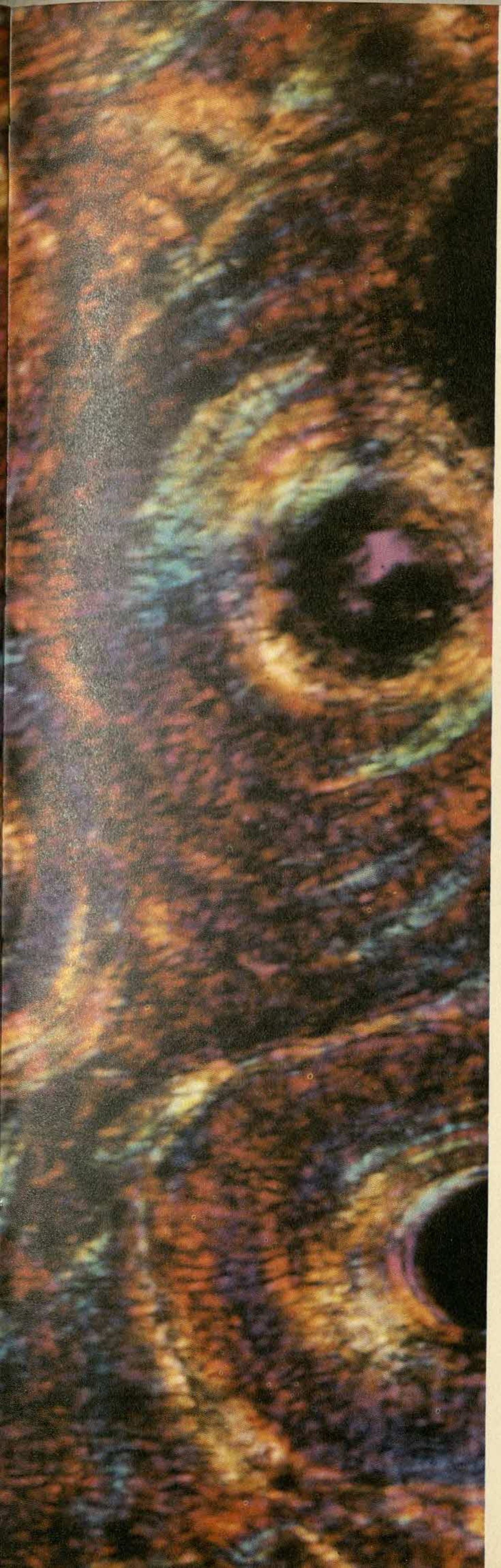
master, at least partly, the great phenomena of growth, cell differentiation, and sexuality.

If for the moment we are nearly impotent in the face of old age, it is because we still do not know the true causes of organic degeneration, in spite of developments that have occurred during the last few years in the young science of old age, or gerontology, of which Francis Bacon, in the sixteenth century, was one of the great initiators with his astonishing treatise on life and death *(Historia Vitae et Mortis)*. But finally, with patience, ingenuity, and technical refinement the causes will be revealed. Certain avenues of research are already clearly marked out and may soon lead to rewarding results.

The duration of life could perhaps be extended to two or three hundred years; this would no doubt be a magnificent gain for the individual, but it would raise many serious difficulties. Even now, with the earth peopled by short-lived men, we shall have to provide for severe measures of control of birth, so as to avoid over-population of our planet. With a race of long-lived men, how will it be possible to secure a proper equilibrium between births and deaths? The dangers of a progressive ageing of the population are apparent for all to see, as are those of a constant increase in the number of inactive citizens in proportion to the total population. Is it possible that the species will renew itself too slowly?

This is just one example among many of the conflict between the interests of the individual and the interests of the species, and such conflicts will become more and more numerous as the power of the biological sciences increases.

⁂



In order for medicine to make further progress, as Raoul Kourilsky shows, research will have to be carried out at cellular level. This will be done with the aid of biochemistry and microscopy. Only techniques involving such a high degree of precision make it possible to localize or diagnose lesions that clinical methods are unable to discover. This microphotograph shows healthy bone-tissue under low magnification. The bone substance is grouped in concentric lamellae round each blood vessel, thus forming Haversian canals. This harmonious design is destroyed by such diseases as osteoporosis or osteomyelitis through progressive enlargement of the canals at the expense of the bone substance surrounding them. (Photo Lod).

The future of medicine

Raoul KOURILSKY

Nothing is more embarrassing for scientists than to be called upon to define the future. They are, of course, familiar with the use of intuition, but only within the framework of controlled experiments. They have learnt to be wary of imagination; and a hypothesis unsupported by proof seems to them almost a crime. However, they do allow themselves to draw up plans for the rational development of premises firmly established in the present. Nonetheless, what is logical is not always biological.

How, then, is it possible to include in a logical whole all that is new, unforeseen, accidental, and which arises from an endless conflict of probabilities impossible to discern in the present? Should we take refuge in fantasy? Or force our powers of intuition? There is no really satisfactory solution. The reader must be prepared to be very indulgent towards any attempt to see into the future.

It is possible to foresee that the realities of today will be those of tomorrow, and that our knowledge of disease, linked as it is with that of the biological sciences, will increase proportionately with these sciences and will be considerably deepened.

Those principles which have transformed medicine within fifty years will continue to do so. As physics reinforces chemistry, and biochemistry penetrates physiology, so shall we gain a knowledge of mechanisms still closer to the true structure of matter itself. These sciences will gradually discover functions, relays, correlations, activators, and modulators.

Even if present-day techniques remain unchanged, there will still be a host of discoveries to be made, in three spheres especially: those of the cellular mechanisms, of hormones, and of the functioning of the nervous system.

The era of investigation at cellular level has begun

Decisive and startling progress will be made in this field. In the near future, histochemistry will be studied by the use of the electron microscope. The chemical structure of visible molecules will be unravelled. Together with 'isotopic tagging', these techniques will allow us to study physicochemical mechanisms with the eye.

Phase-contrast cinematographic study of living cells on the one hand and the study of enzymes on the other, lead to an understanding of intracellular regulation. The science of genetics will relate these to molecular structures.

There is no doubt that a new kind of medicine is about to emerge: that related to cell diseases. Rudolf Virchow's old dream of studying disease by starting from the cell will come true, though in a somewhat different way; Sir Roy Cameron has already published a text-book on cellular pathology.

Medicine will go further than this: it will connect many diseases with events at molecular level, and will determine those resulting from acquired or innate biological error. Molecular pathology is already an established part of medicine. The broad outlines have been mapped out: developments will follow swiftly.

So far, knowledge of diseases caused by environmental factors has benefited most from biological discoveries; now it is the turn of those diseases which are apparently unrelated to their environment and arise mysteriously within the body itself, developing without visible cause or possibility of medical intervention. These diseases will gradually be explored and probably brought under control.

There is one disease which should benefit especially from this research, and that is cancer. Disorganized and unrestrained cell growth implies irreducible disturbance of normal balanced growth. A knowledge of normal cell-reproduction mechanisms and regulation is therefore an imperative requirement for the ultimate understanding of cancer. Whether it is of viral origin—which has not been proved in man—or whether it is brought about by molecular damage of distant genetic origin, the solution to the problem lies in the control of cell growth.

It must not be thought that the solution will be found easily or soon. The more we probe, the more difficulties we find and the more we become aware of our inability to grasp the basic factors involved. Of course, it is possible that we may be put on the right track by some incident or discovery in another branch of medicine—this has often happened before. All that can be said at present is that the time is not yet ripe.

It is likely that the mechanisms of a disease are set in motion long before it becomes apparent and genetic factors intervene. Much time and research will be necessary before we are in a position to prevent or arrest the development of cancer.

One day, however, the reduction and prevention of cancer will undoubtedly be achieved by the introduction of growth-restraining principles.

Looking back, our descendants will be horrified to think that for so many years we were obliged to resort to the blind destruction of great masses of cells, using electron radiation, instead of merely re-establishing normal growth equilibrium physiologically by oral or sub-cutaneous administration of chemical agents capable of restraining growth.

The same considerations apply to leukaemia, Hodgkin's disease, lupus erythematosus, and all the dread diseases that we do not yet know how to cure.

The possibility of detecting damage to chromosomes and progress in understanding genes will certainly help in guarding against certain genetic diseases.

A branch of medicine that should one day benefit from research in molecular physiology is immunology. This science has now

S.C.E.R.T., West Bengal
Library
Calcutta
25/3, B. C. Road

reached cellular level, but the defence mechanism of certain cells (leucocytes, histiocytes) against microbial agents is still little known. For instance, there are bacteria which remain viable and capable of pathogenic action for years on end within a man's body without causing him any apparent distress. It is already known that the absence of certain substances secreted by the cells prevents the destruction of pathogenic agents. One day, instead of using antibiotics prepared from vegetable matter, we shall probably discover how to make use of the essential organic processes which prevent bacterial growth, and thus include many new substances in our preventive armoury against infection.

The era of hormones is far from closed

The action of new hormones is continually being suspected and demonstrated. Only a few years ago the presence in the blood of a substance which caused the bone marrow to produce red corpuscles was demonstrated physiologically. Biochemists have been able to isolate this substance from the blood and to study the chemical composition of this erythropoietine, the concentration of which in the plasma governs the production of red corpuscles. This hormone is not secreted by any of the organs which would normally be expected to be active in erythropoieses (bone-marrow, reticulo-endothelial and lymphatic systems, pituitary), but by the kidney.

Anaemia and polycytaemia must now be interpreted in the light of the action of erythropoietine, and the effect of cobalt on production of erythropoietine has been discovered.

It is hardly necessary to emphasize the importance of these facts; in particular it is permissible to assume that the production of white corpuscles is also likely to be regulated by hormones, and that it is a disorder of this kind which occurs in leukaemia.

Recent research has shown that the opening and closing of the Oddi sphincter at the opening of the bile duct into the intestine, which controls the discharge of bile coming from the liver and gall bladder, is controlled not only by the nervous system but also by the action of a hormone secreted by the intestine, identification of which is not yet complete.

In the years to come, hitherto unsuspected hormonal actions will be ascertained. Hormones, thought of at first only as regulators of metabolism, are more and more coming to be regarded as substances which, acting through the metabolism, control innumerable cell and tissue functions.

Knowledge of the nervous system

It is possible to foresee decisive progress shortly being made in this sphere. The great international organizations have felt that this will be so, and throughout the world institutes have been established to confront this fundamental problem.

It is already known that not only peripheral but also central nerve impulses are conveyed through chemical substances liberated on the spot; and that the pituitary, as the central control-point of the endocrine system, is stimulated chemically by secretory signals from the central grey cells, which in their turn are influenced by chemical substances originating in the higher centres of the brain. The connection of the autonomous nervous system between hypothalamus and frontal lobe has been shown. Special nerve fibres, the action-currents of which can be measured, have been discovered. The part that they play is also chemical.

This is the point of departure. Innumerable anatomical, neurophysiological, and pharmacodynamic discoveries will follow, by means of which we shall be able to influence different stages of the activity and highest functions of neuraxons.

Opposite page: Prosthetic surgery will become extremely efficient in dealing with all kinds of accidents. Because of the development of plastics, it is now possible to replace amputated limbs by artificial ones which can be made to look exactly like parts of the living body, and which to some extent lessen the psychological consequences of the accident or illness. Which of these two hands is the artificial one? We leave it to the reader to guess. (Photo Lod, taken at the Hôpital Saint-Antoine, Paris).

Opposite page: The recent resounding successes obtained with vascular grafts were the outcome of careful research and experiments conducted on animals. This illustration shows part of a rabbit's ear onto which has been grafted a small piece of tissue taken from another rabbit. The vessels of the grafted piece have grown and have made connections with the vascular system in nearby areas. Such experiments give reasonable hope for the time when sclerotic or deficient vascular systems can be largely replaced by grafts. (Photo Lod).

Nervous and mental diseases will benefit from these new biological discoveries; the present stage of knowledge in this field can be compared with that of the condition of patients suffering from nutritional diseases before the discovery of hormones.

In fact, all our understanding of diseases will be changed. Reactions to a given disturbance and excitation affecting particular effector organs vary from one person to another and the cause of these very wide variations is still unknown. It resides in a particular variable condition of the nervous system, which we do not know how to measure or evaluate, in spite of the fact that it causes the most astonishing differences in the manifestations of diseases.

The mastery of neurophysiological regulatory processes is involved in these investigations. We know how to measure arterial pressure, but not nervous tension. We do not even know what it consists of: its effects are known, but none of its basic physical constituents. It remains the great unknown factor, without which the tremendously important science of regulatory systems cannot advance. Lack of knowledge about circuits, uncertainty regarding commands, secrets of feed-back and of regulatory loops, both as to their location and nature, will stand in the way of mathematical physiology for a long time to come.

It is therapeutic medicine that will gain most from many future achievements: new chemical substances acting selectively on certain mechanisms of the nervous system, and better understanding of synergic and regulatory processes. Surgery will be used for this purpose. Psychoneural surgery has an important future.

But it is preventive medicine that will be most changed as a result of research carried out in the three above-mentioned fields. Preventive medicine will seek to check and delay metabolic diseases, in particular atherosclerosis, one of the chief causes of death in highly developed societies, with its long succession of coronary attacks, infarction, and cerebral injuries.

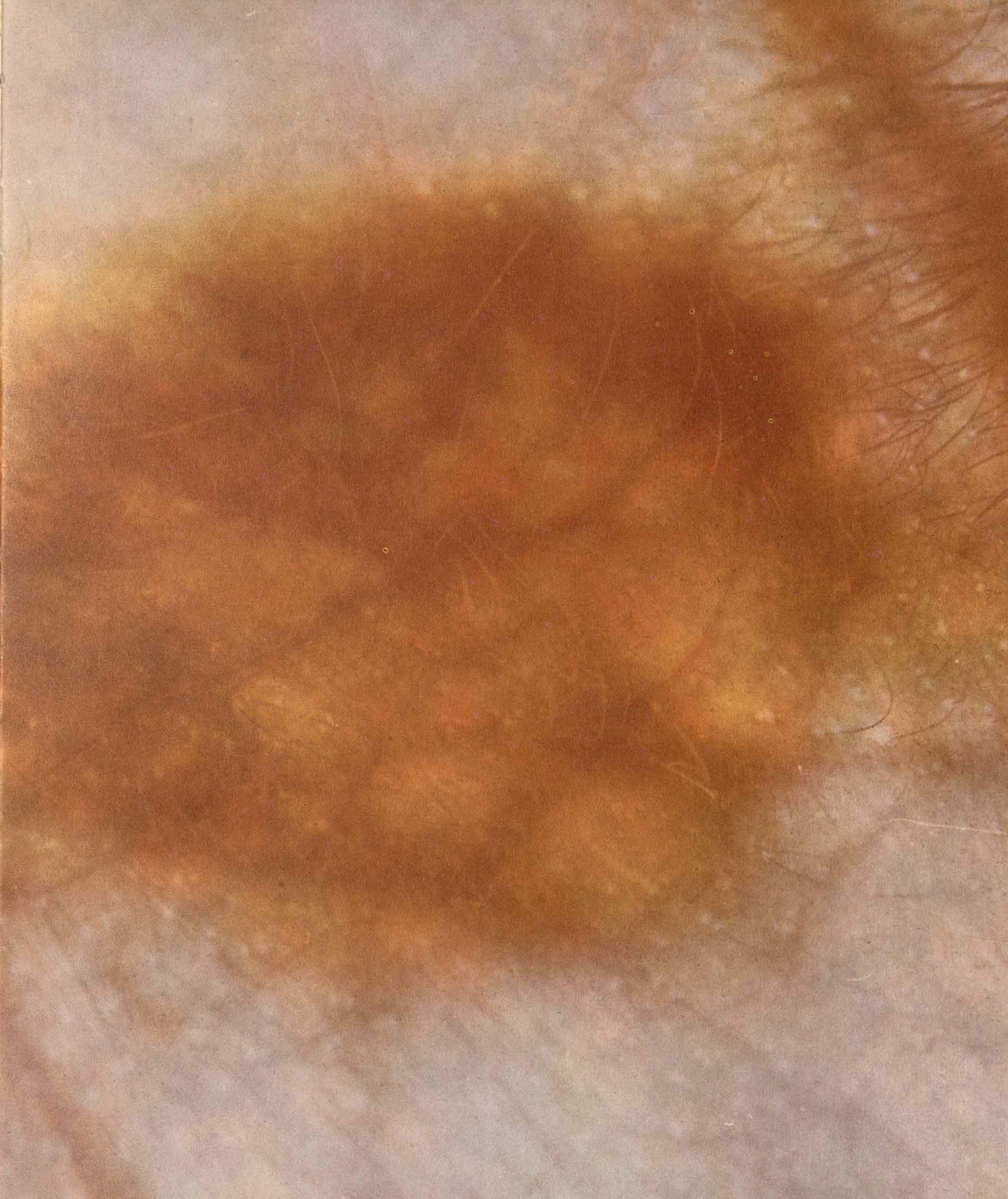
The future of disease

It would be a grave mistake to think that because of this basic research and the minutely regulated treatment which results from it, the human race will be freed from disease. This would be to ignore the fact that man is the prisoner of his environment—the environment from which spring two-thirds of the diseases that afflict him, the environment which he is continually transforming while at the same time suffering the consequences of those transformations.

No doctor or biologist doubts what would happen in the event of massive world-wide atomic destruction, quite apart from the danger of radiation. Even without these disasters, peacetime society is capable of creating disease. For example, atmospheric pollution has increased the number of people suffering from chronic bronchitis and emphysema because it stimulates chronic bronchial infection which can thereafter prolong itself indefinitely. In England, in 1951, 37,000 people died and 266 million working hours were lost because of this, and this figure is valid only for that section of the population that pays insurance contributions.

Expansion of mechanical industries, increase in the number of motor cars and aircraft, and in the number of people who go in for winter sports, has given an importance to accident surgery which it will not lose yet awhile.

A specialized type of medicine will be necessary to deal with the environmental extremes to which men are now subjected; for instance, there will have to be special branches of medicine for the treatment and prevention of disease resulting from space-travel and under-water exploration.



Less spectacular, but of no less importance in their general effect are psychological factors created by present-day conditions of human life. Reacting on the individual, these factors cause people to become depressed, over-excited, neurotic, or psychotic. Throughout the whole of society, the upsets in the rhythm of every-day life caused by the necessities of industry bring about emotional disturbances which many people either do not know how to master or cannot master. Lack of work creates boredom which people try to avoid by the use of very varied stimulants. The effect of the monotony of automation has already made itself felt.

It is certainly possible to find a solution in sedatives and tranquillizers; consumption of these is already excessive, but they do not prevent psychological disorders from increasing dangerously.

As René Dubos has said, 'Custom, habit and taste alter so rapidly that we do not have time to adjust ourselves to them'.

To help modern man to cope with these rapid changes, we do not need psychiatrists, but psychologists with a wide knowledge of ecology and anthropology. This branch of medicine also has an important future.

Contrary to Aldous Huxley's sombre prognosis, individual medicine will survive all attempts at collectivization. Instead, medicine will become much more efficacious through the increasingly active part played by the patient himself, who will be much better informed regarding his own body and psychological problems.

As our understanding of the body's mechanisms increases, so great changes will occur in traditional therapy: active drugs will be carefully limited and known formulae effective in regulation of disorders will be used to calculate the quantities of substances required to restore biological equilibrium. Prescriptions will no longer be issued empirically, but specifically with the minimum of error, and their use will be much more strictly controlled than it is today. Quite soon, medicine, like engineering, will be able to make use of slide-rule calculations. The day will come when we shall be both pitied and admired for the way in which we have to restore health under the empirical and uncertain conditions of today.

Re-establishing the body's equilibrium will no longer be the work of drugs alone; medicine will make more and more use of all the physiological and psychological procedures of re-education and re-conditioning.

⁂

The hope of the future lies in the detailed use of these procedures, with the minimum of medication. Prosthetic surgery will also become extremely efficient in dealing with accidents.

Thus a considerable change will occur in the practice of medicine, when the doctor will be able to follow the course of a disease with the care of a biologist, and at the same time to watch his patient with the enlightened interest of the psychologist.

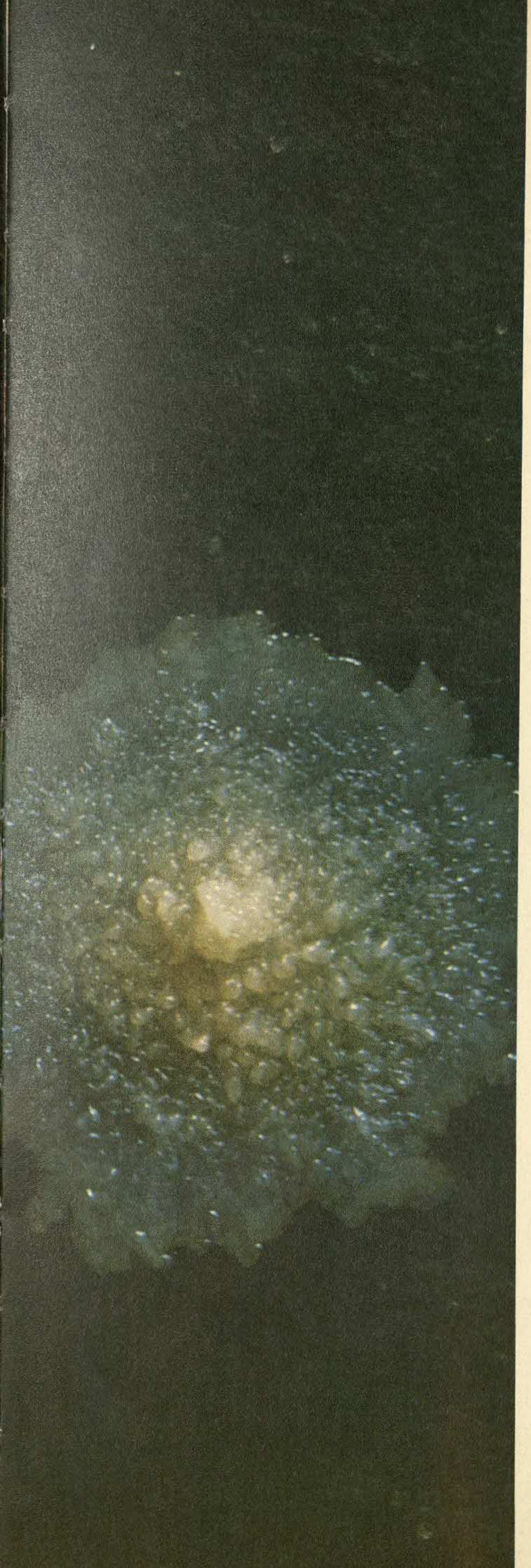
Medicine and the human race

There is little likelihood that medicine will eliminate disease from the human race. Both the human species and its environment will provide other diseases. Certain people even think that medicine will make men more vulnerable because it will take too much care of them; with Alexis Carrel and H. J. Muller, they believe that it will create unfavourable genetic conditions by allowing the weakest to survive. Dubos even believes that excessive worry over protection from pain could lead to social and racial suicide.

G. K. Chesterton complained that the fault with the medical outlook is that it suggests a connection between health and caution. This is a mistaken attitude towards the aim and scope of medicine. There is no medical outlook on life; this is something which only those who are depressed and anxious can be said to have, and they are in this condition for reasons which have nothing to do with diseases either of the past or the future.

The aim of medicine is to maintain or re-establish a man's health; that is to say, to ensure or restore to him the free use of his physical and psychological faculties. The role of medicine is to adapt man to his manly status, and this does not depend on medicine. A man may be brave or cowardly, an individualist or a conformist, committed to or indifferent in response to the prevailing mood of society and his own efforts at achieving some kind of personal philosophy. Here medicine has no authority. The responsibility belongs to man and to those social groups to which he adheres for better or worse. But if, by chance, the authorities were to ask medicine what it knows of man, medicine would say, 'Educate man; teach him that he is not alone in the world, but that he exists in an environment that undergoes continual change, where the unexpected is the rule and probability the law, where death is the only definitively stable state, where a constant effort must be made in order to survive, and where this effort must be related to that of others, since this is the price of survival.' But will this be understood?

⁂



Are there still further pathogenic bacteria to be discovered? It seems likely. Even those that have been identified have not yielded all their secrets, and the microbiologist still has a difficult task before him. (Photo Lod).

The future of microbiology

Albert DELAUNAY

In the district of Beauce in Northern France there is an isolated farm called Saint-Germain-la-Gatine that fills me with emotion whenever I see it. From it, one can look out over the huge plain to the distant horizon where the beautiful spires of Chartres cathedral soar upwards. It is a splendid sight. Unexpectedly it has been described by a bacteriologist, Dr Emile Roux, who was one of Pasteur's pupils. Less than a century ago, in 1882, Pasteur came to this farm to begin his researches on anthrax. A tremendous amount has happened during the intervening period, a period of success and triumph for microbiology.

First, the principal bacteria were identified; then it was discovered that in some of them there existed toxins, and it was these that made bacteria so dangerous. Shortly after this, another group of pathogenic agents besides bacteria were discovered—viruses. At the same time, the biologists who were trying to find out how the body normally defends itself against bacteria and viruses discovered two important mechanisms, one chemical (in this case, antibodies), the other cellular (found in certain cells called phagocytes, which are able to absorb germs and then destroy them). In many cases, these two mechanisms are capable of neutralizing the attacks of very small germs, but occasionally they are not able to do so. It was therefore natural that biologists should try to find a method of protecting the body, using powerful therapeutic means. It is truly marvellous that their search resulted in success: I refer, of course, to the amazing discovery of vaccines, sera, sulphonamides, and penicillin. Although the danger from germs still persists, it no longer has the mysterious and terrifying aspect that it had in the past. This does not mean that microbiology has no future, or that the whole subject has been investigated and dismissed as complete. In fact, microbiology today is extremely important. Innumerable problems await solution by microbiologists; it is these problems which I should like to outline briefly here.

It is probable that there are further pathogenic bacteria to be discovered, and though the most important of them have been identified, even these have not yielded all their secrets. The bacteriologist of 1965 faces various tasks: improvement of culture media (for the purposes of facilitating diagnosis and obtaining more active toxins), adding to our knowledge of the physical, chemical and antigenic nature of micro-organisms, perfecting new formulae for vaccines (antibacterial or antitoxic), discovering new methods of treatment for the better understanding of the action of antibiotics. Bacteriologists are also responsible for isolating strains capable of benefiting agriculture and industry. This is a considerable programme, but there is still more to be done. Today, bacteria are the most suitable material for use by those wishing to probe the innermost secrets of cellular life. Physiologically speaking, this entails the study of innumerable metabolites. Such studies have already been made on animal and plant tissues, but bacteria are apparently more convenient and manageable. In fact, there seems to be no end to their possible use. Both now and in the future, all branches of biology, including the science of heredity, can profit equally from the bacteriologists' work.

Meanwhile, the science of virology covers an ever increasing field. Not all viruses have yet been identified, as the recent discovery of the E.C.H.O. and 'orphan' viruses shows. Perhaps viruses are innumerable. Certainly not all of them are pathogenic, as was thought in the past; but they may all be potentially pathogenic. I refer in particular to malignant disturbances; more and more reasons seem to point to the viral origin of many types of cancer. Already certain viruses have been identified as being capable of inducing neoplasms in animals and plants.

From a general point of view, too, a great many things can be expected from the study of the virus. It is known that some viruses are so simply constructed that they consist only of nucleoproteins. What are we to make of this? Are we dealing with very degenerate germs, or with living matter in the process of constructing itself out of raw material? This burning question which is not merely philosophical should be solved in the near future. Thus the spheres of bacteriology and virology extend *ad infinitum.*

Let us turn for a moment to the other aspect of microbiology: immunology. In this field, past research has shown that among our best defences against bacteria and viruses are the special cells known as phagocytes, and special chemical substances known as antibodies. These discoveries are splendid achievements, but do they provide sufficient reason for abandoning hope of other important new discoveries being made? With regard to phagocytes, I shall repeat what I have already said about bacteria: they are cells that are easily isolated and handled. There will be many surprises in store for us when we finally discover their innermost workings.

At present, a whole new chapter on phagocytosis is being added to the annals of microbiology. A few years ago, it was justifiable to think that the majority of bacteria seized by phagocytes would be destroyed: in fact, this does occur in many cases. But, as we have seen in the case of recent *in vitro* culture of certain phagocytes (monocytes and macrophages)—a method used on a large scale since 1955—the destruction of the foreign body is by no means certain. Sometimes, the bacterium which is buried deep in the cytoplasm resists the enzymes and strong bactericides surrounding it, and although its structure, chemical constitution and physiology are altered, it still survives. Detailed study of this phenomenon should explain certain states, not yet clearly defined, through which the body passes. Thus in a state of precaution the body can only resist an attack by virulent micro-organisms if it harbours living attenuated micro-organisms of the same kind: an example is tuberculosis. Furthermore, examination of phagocytes cultivated *in vitro* has shown that in other cases the cells, far from wholly or partly destroying bacterial elements, can in fact encourage them to spread. Thus it can happen that bacteria, having penetrated the phagocytes, start to multiply just as if the cytoplasm of their host had provided them with the various chemical substances they needed for reproduction. What explanation can there be for this occurrence, which is by no means rare and has been observed in the case of tubercle bacilli, *Brucella* and *Bacillus tularensis*? No solution has yet been found. In the last analysis metabolic phenomena are almost certainly responsible—but which phenomena?

When microbiology was a new science, antibodies were regarded merely as useful substances placed at our service by provident Nature. Antibodies protected us against microbes and their toxins. Their detection and dosage was useful in providing information about our natural immunity (whether they act alone or together with the blood complement(1)). A little later, after the discovery of allergic phenomena, they gave grounds for some fears. These concepts appeared to be over-simplified and did not satisfy us any

(1) Complement: *Normal blood constituent, forming part of the body fluids' defences.*

Opposite page: Modern biology is directed increasingly towards physico-chemical studies of cellular cytoplasm. For these studies bacterial cultures such as the colonies of Serratia marcescens, *shown here in red, and* Pseudomonas violatea, *shown in purple, are particularly suitable. (Photo Lod, taken in Professor J. G. Marchal's laboratory, Université de Nancy).*

more. During the last few years, both the concept of antibodies and the corresponding concept of *antigens* have had to be completely re-examined, which is as much as to say that they have been transformed. Now, it is believed that the action of antibodies and antigens comprises general physiological phenomena which are of more general significance than their purely imminological function. This increases their interest; they concern many more biologists. Among the educated public of 1965 there can be hardly anyone who does not understand the meaning of the words antigen and antibody.

These substances should certainly interest the physiologist, though pathologists are also involved, since it now appears that certain chronic disturbances, whether in animals or human beings, may well be dominated by subtle antigen-antibody reactions. As an example, I would mention briefly Hashimoto's disease. This is a chronic thyroid disturbance which nearly always affects women only. If it is not treated, serious consequences may ensue owing to too much or too little hormone secretion. Until lately, the origin of this disease was unknown. Now, however, there are reasons for surmising that the following events occur: at some point the body would begin to manufacture antibodies against certain substances—these may or may not be hormones—which are normally present in the thyroid. These antibodies would combine with the substances in question and form precipitates in the gland, and the clinical picture of the illness would gradually emerge. The reader may well ask, why the untimely proliferation of antibodies in this case? It does not occur normally. This is a good question, though unfortunately there is still no answer to it. Once again, we must look to the future. Luckily, in the case of Hashimoto's disease there are efficacious preparations such as antihistamines and cortisone which can be used to suppress the unusual reactions typical of this disease.

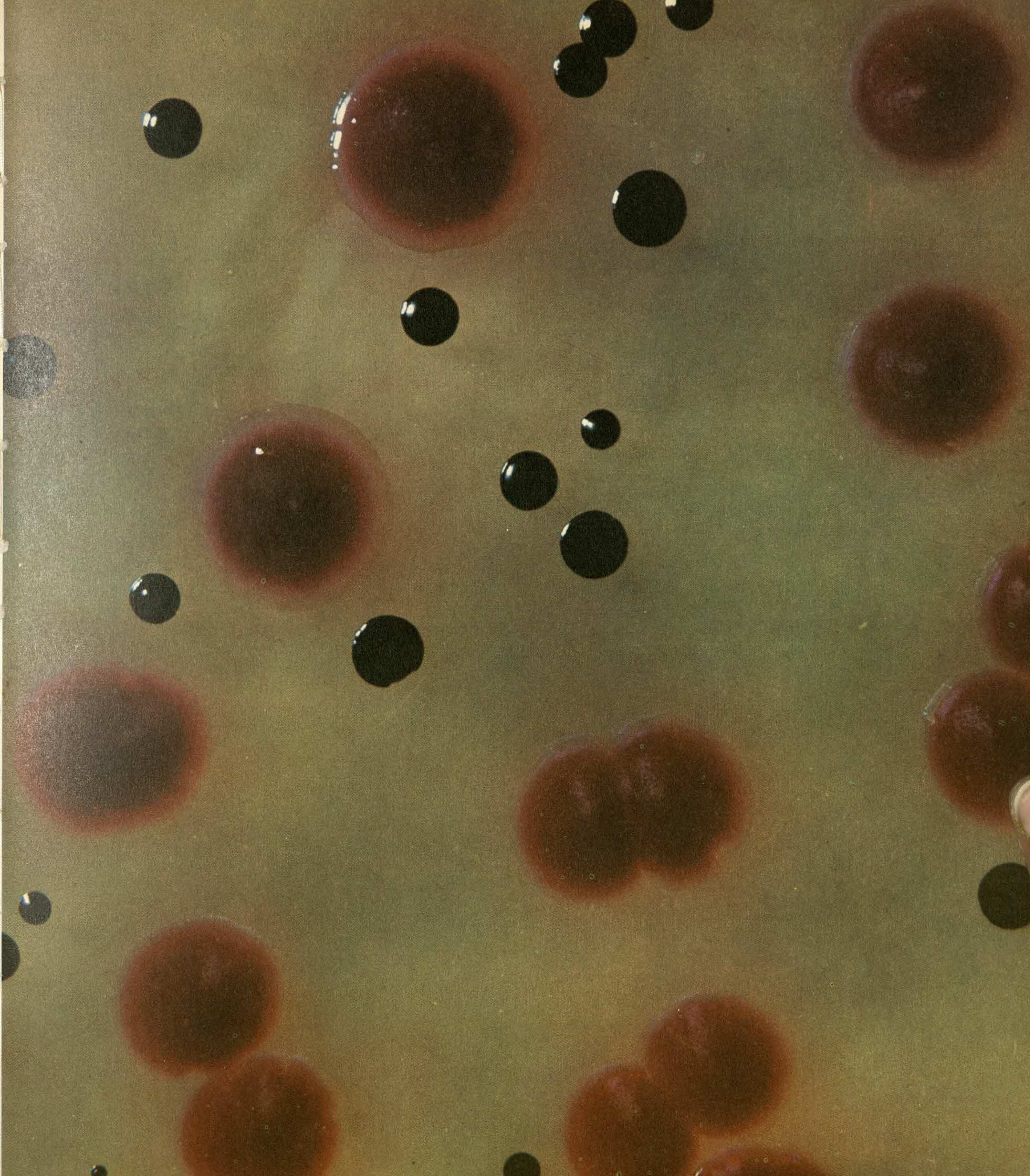
During the last twenty years, one of the major achievements of immunology has been the revelation of certain vitamin and hormone actions. Convincing experiments have shown that our resistance to infection depends largely on the level at which these substances are maintained in the body. Thus excess secretion of cortisone can aggravate the development of certain forms of tuberculosis and activate bacteria which had previously been dormant. Such a fact is extremely interesting. It means that immunologists must have a solid knowledge of endocrinology; indeed, it must be admitted that all branches of biology are interlinked.

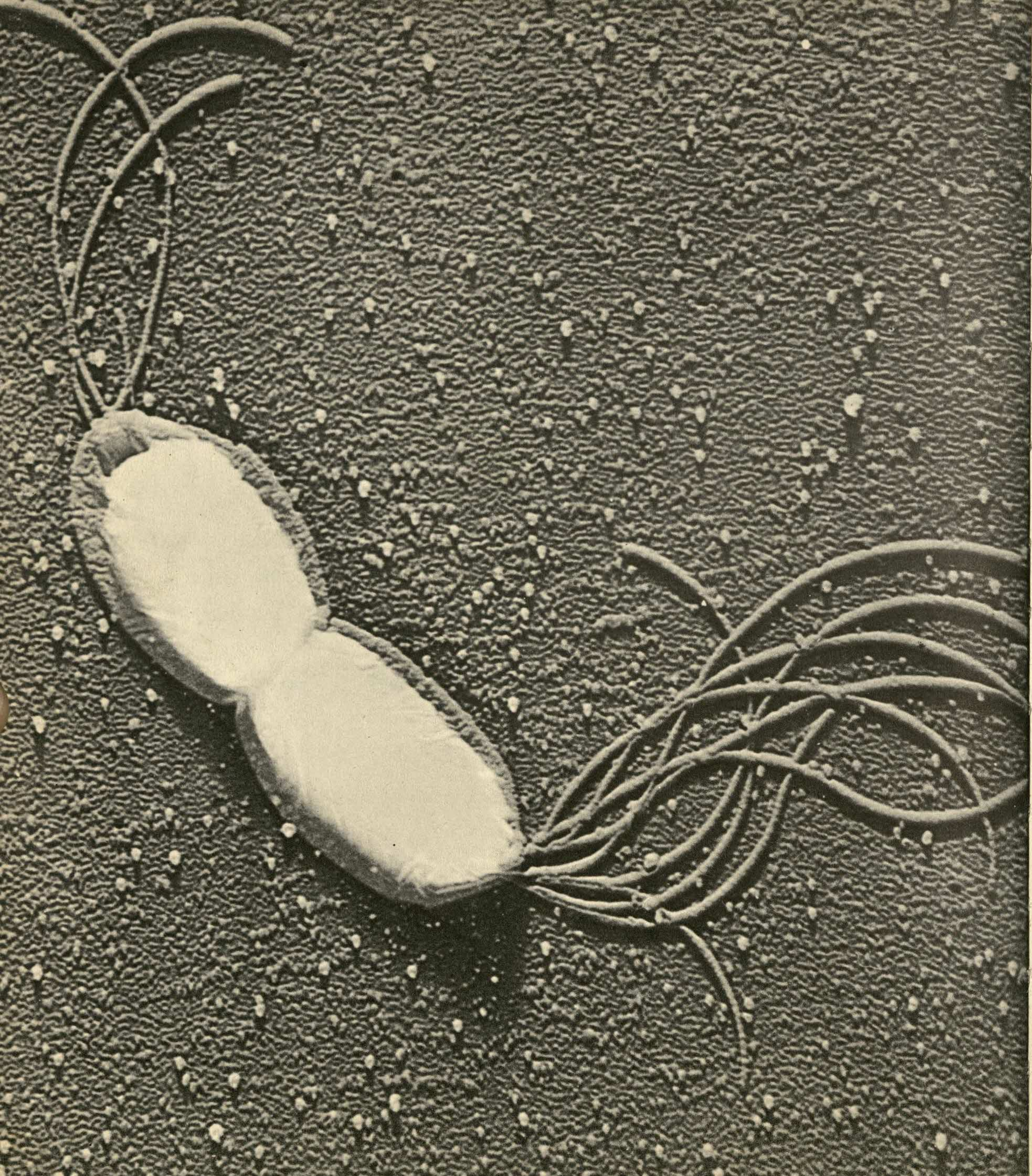
Present-day microbiologists should command the whole field of biology, but obviously this is impossible; the only answer is team work. A short while ago, one man with a few pieces of equipment could achieve a tremendous amount. Nowadays, more often than not, unless an idea is initiated, backed, and developed by a team of several research workers, there is little likelihood that it will ever mature.

Thirty years ago, when Jules Bordet, winner of the Nobel Prize for medicine, was lecturing at the Institut Pasteur, he used to say, 'Those of us who witnessed the beginnings of microbiology were more fortunate than you are today. Then, very little work was necessary in order to discover something new. But nowadays . . .' He was right, but while the microbiologist's task has become increasingly difficult, it throws light on far wider horizons.

Finally, let us consider the realms of biochemistry and biophysics. Pasteur and Duclaux were both chemists, and as the latter has said, 'Chemistry has medicine in its grip; it will never release it'.

It would be permissible to claim that of all today's scientists, the biochemist is supreme, above all, if at the same time he is a biophysicist. I remarked earlier that the microbiologist should also be a physiologist, and





this is true. But physiological discoveries will be of no real value unless the biochemist steps in and indicates which the active substances are and what their constitution is. Thus our knowledge of metabolism was restricted until purified enzymes were used. A bacteriologist who is also a biochemist is better equipped than anyone else to isolate the most important constituents of bacteria, because he can tell us how these constituents are formed. Similarly, the immunologist who is familiar with chemistry is also fortunate, because it is he and he alone who will be able to discover the key to so many phenomena. He will achieve this by making detailed studies on antigens, antibodies, interferon, complement, chemotactic substances, etc. In the past, we were only able to describe inflammation in morphological terms, today we understand the kinetics of it because Menkin and others who came after him have shown us which substances act in this process. This result has been achieved because these immunologists were also biochemists.

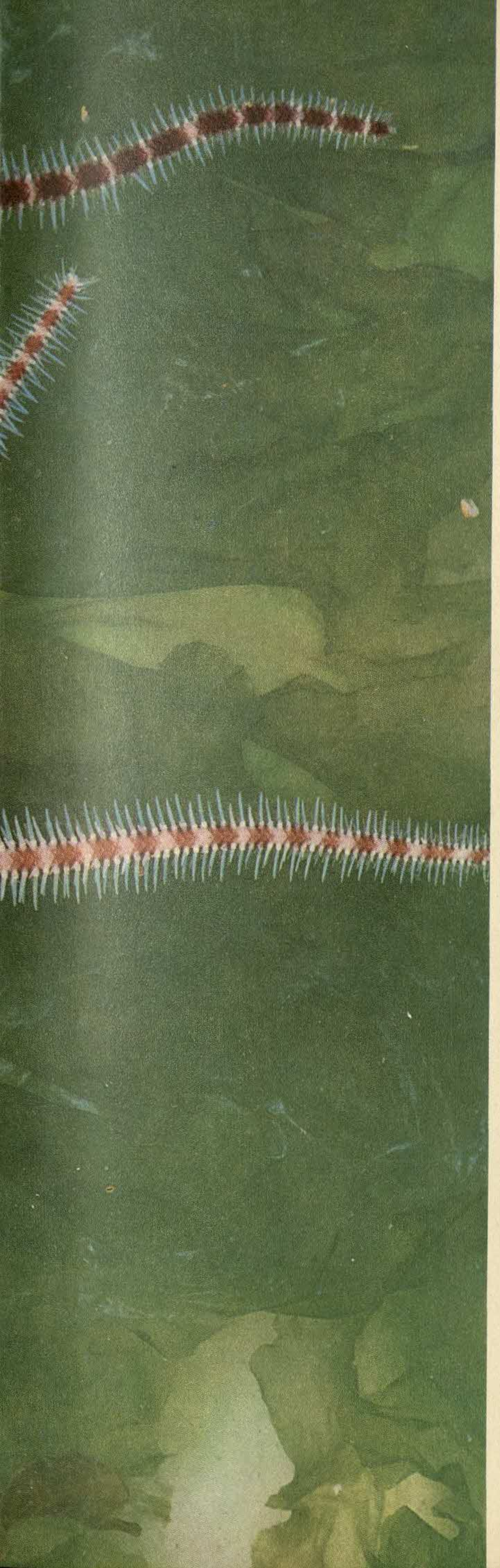
It would be excessive to claim that this general intrusion of biochemistry is revolutionary. In fact, although its importance could be foreseen from the start, it continues to astonish.

What is the future of microbiology? I have stressed in some detail the direction in which science will progress and what new triumphs can be expected from it. I must emphasize one more point: more than in the past, bacteria and viruses will be studied as entities in themselves because they can teach us so much about the multiple unknown facets of life. Doubtless they will also continue to be studied as factors in serious diseases. Already, nearly all of them have been identified, and this is a great advance. However, we still have to discover the deep reasons why one strain should be pathogenic and not another, why such and such a micro-organism attacks certain organs and not others. We still have to find out why bacterial multiplication in the body is sometimes slow and sometimes explosive; why in certain cases (particularly with viruses) the resultant disease is periodic; why certain diseases never occur more than once (typhoid, for example) while others (as happens in the case of staphylococcal infection) can reappear in the same individual at different stages in his life. All these obscurities should be dispelled.

Can we have confidence in the microbiologists of the future that this will happen? I would answer unhesitatingly, 'Yes'.

⁂

Opposite page: The microbiologist should command the whole field of biology; above all, he should understand the problems of genetics, as well as those of the sexuality or cell division of bacteria, as shown here with the help of the electron microscope. (Photo Dr Scanga, Istituto Superiore di Sanità, Rome).



The elegant outline of these echinoderms (brittle-stars) with their long flexible arms has been found in shale dating from the Devonian period. Four hundred million years have elapsed between the origin of this type of animal and the present day. Man is a late-comer on the earth's surface; he first appeared there only 500,000 years ago. To the biologist considering the future of the animal world, it is of great interest to compare the stability of certain species over the centuries with the rapid evolution of man. He may wonder whether the decline of our species will not be as sudden as its rise. (Photo Lod).

The future of the animal world

Rémy CHAUVIN

It is difficult to discuss the future of the animal world because those sciences concerned with it are either in their infancy or, as in the case of taxonomy, they are almost entirely descriptive and are not capable of accurately forecasting the future.

First, we should ask if there is any place at all for animals in our technical civilization. As man strengthens his grasp upon this planet, so his cities assume monstrous proportions, killing nearly all life coming within their boundaries. In Paris, only pigeons, sparrows, rats and mice manage to survive, together with the inevitable insects, which I shall discuss later. Even in the countryside, hunting and shooting are pursued with a fervour unknown in the past. During the shooting season, around Paris guns are lined up at intervals of only three or four yards and thus are able to beat the countryside very thoroughly over an immense area. Every species hunted in this way would have disappeared long ago were it not for methodical restocking of game at the end of each season. In certain areas of southern France, and especially in the south-west, things are very different. Vines occupy most of the land, so there are no trees or bushes and the countryside is under almost constant cultivation; here game can find hardly any shelter. On the other hand, the detestable habit of hunting small birds, which are regarded as one of the principal delicacies of the region, depopulates whole areas of their feathered fauna. I well remember my amazement when, as a countryman from the north-west of France, I first came to these localities devoid of animal life, having been used to the thick hedgerows of Normandy and Brittany which abound in protective undergrowth and provide shelter for such varied fauna.

Since civilization has taken a firm hold, a considerable number of species have disappeared—many birds and several mammals. Whale-hunting has had to be severely restricted and whalers are strictly limited to catching small quotas. If this had not been done, that huge mammal would long ago have disappeared from the oceans of the world. Two or three hundred years ago, the beaver was very common in the Paris area, as can be seen from several place-names, such as Bièvres (the name of beaver in old French). It was hunted to such an extent that now it is to be found only in certain areas of the south of France by the banks of the Rhône. If allowed to do so, hunters would completely exterminate the beaver, doubtless for no reason other than the cruel pleasure they derive from killing.

Fortunately, nature reserves have begun to be established, hunting permits are severely restricted, and some species are completely protected. Perhaps the obscure impulses that turned man into the blind destroyer of nature have finally been exhausted. If so, there is hope for quite a number of species which at the moment are on the point of extinction.

Nevertheless, it should be remembered that all the large mammals without exception exist only because man allows them to do so; if it were necessary, their destruction could be accomplished in a very short time. This, however, does not apply to insects. In their myriads of species (probably two or three million; and every year several thousand new species are identified) they are the only creatures to have been partially successful in their fight against man, who is only able to hold them in check by combining all his resources. Two examples will suffice: periodic invasions of locusts still devastate large areas of crops, in spite of highly organized anti-locust campaigns; the damage they cause can only be kept within bounds by using large numbers of aircraft and helicopters for spraying insecticides, and by employing large teams of watchers. I was in Morocco during one of these locust invasions and was surprised at the way in which the head of the anti-locust service was granted immediate telephone and telegraphic priority with the two magic words: *locust warning*; this password could cause trains to be re-routed and summon convoys of lorries loaded with insecticides. You only have to see a cloud of locusts to understand why.

I shall take as my second example, ants. In Volume II, devoted to the study of the animal world, we have been told of the only example of their usefulness, which is against forest insects. Otherwise, man spends most of his time trying to find a way of getting rid of ants. The Americans have to contend with the problem of the burning ant *Solenopsis saevissima.* This can inflict painful bites, and it invades fields, disorganizes whole districts, and makes farming difficult and unpleasant. In the south of France the Argentinian ant is to be found. This is a tiny but amazingly prolific little insect which causes serious loss from damage to the houses it chooses to invade. It does not attack man directly, but it gets into everything, including bread, coffee, and especially bedclothes. In theory, it is possible to combat this ant by putting poison on some form of sweetened bait at certain times and in certain places, but the bait must not be left too long in the same place because the worker ants learn to avoid it, as do rats, so that it is extremely difficult to maintain a regular campaign. A few years ago, a colony of these ants installed themselves surreptitiously in the Institut Pasteur; the staff's consternation may be imagined when they discovered that a party of worker ants had eaten away the cork of a jar containing a culture and were in the process of spreading a terrible virus all over the building. Moreover, it was a virus that was harmless to the ants themselves, because ants are practically immune to human diseases, as well as to atomic radiation. During experiments with radioactive tagged isotopes, which I have carried out with various colleagues, active phosphorus was given to *Formica polyctena* in amounts that would have caused several human beings to succumb. Insects, however, are much less sensitive than humans to the deadly particles. In my view, it is quite inaccurate to assert that in an atomic war every living thing would perish; on the contrary, insects would survive, together with many other invertebrates. The vertebrates, above all man, the most wicked of all, would almost certainly be completely wiped out.

The establishment of nature reserves will not be enough; for the struggle against insects we shall have to ban the widespread use of insecticides, about which we know practically nothing, against insect populations of which we also know very little. The general public is not aware of these problems, which have been discussed by Dr Pierre Grison in *The Animal World.* It is possible, however, that our grandchildren will look upon such practices with amazement; for they are only justified by commercial interests. The consequences of the use of insecticides are quite terrifying, but only experts are aware of them. Certain insecticides sterilize the ground partially or

completely over a period of several years, or else they disturb microflora and fauna (which form humus) so severely that no one can foresee the consequences.

Certain reactions against these practices are already apparent: most important is the emphasis on biological method. Where possible, we try to cultivate parasites or predatory organisms to prey on the insects that destroy our crops. For several years, interest has been shown in studies on the substances which attract or repel insects. Butenandt, winner of the Nobel prize for chemistry, has isolated several of these substances in their pure state; he has also succeeded in isolating sexual substances secreted by the female which attract the male as magnets attract iron filings. Many other possibilities exist, and it is possible to foresee a time when we shall no longer resort to a crude and empirical use of insecticides, but will confront our enemies in the insect world with infinitely more precise and selective weapons.

In a chapter devoted to the future of the animal world, it may seem odd to mention domestic animals. The process of domestication, however, which has gone on for so long with such important results, is perhaps not yet at an end. Throughout the centuries the domestication of animals has had very varied objects. There have been considerable fluctuations in the number and types of animals kept for pleasure, although strictly speaking not domesticated. For example, we keep rare and marvellously coloured fish which were unobtainable fifty years ago, or which were a luxury reserved for rich men and aristocrats. In the Middle Ages there were several such men who kept very sophisticated zoos; nor were these confined to Europe; Aztec and Inca princes also owned them. It is likely that 'ornamental' animals, like orchids, will become over-popular.

With regard to the real domestic animals—that is to say, those animals that work in the service of man—none is likely to be added to them, except perhaps the dolphin. The very advanced studies made by the Americans on this animal have shown that the old Greek legends about the dolphin's friendliness towards man are not without foundation. It is possible to play with a dolphin as one plays with a dog; it is just as friendly and affectionate towards its master and appears to have a highly developed intelligence. In the near future, we shall be forced by rapidly increasing populations to exploit the sea rationally, because present-day methods of fishing are crude and uncertain. Deep-sea divers aided by dolphins, which could certainly be trained, will eventually be able to watch over, direct and defend against their enemies the innumerable shoals of fish which at present are decimated in blind fashion by nets and trawls. It is pleasant to think of the dolphin as the sheep-dog of the sea.

Leaving the field of immediate possibilities of application, it is evident that there are still considerable gaps in our exploration of living creatures. This is due to the immaturity of biological science itself. The classification of plants, however, is almost complete, at least on the earth's surface, and it is possible to study nearly every plant in the world in museum herbaria. Classifications of birds and mammals only lack a few details, and there are hardly any gaps in our knowledge of amphibians and reptiles. This is not the case with regard to invertebrates, especially insects, and our knowledge of submarine life is very imperfect.

Everyone has heard of the bathysphere and the exploration of ocean deeps. As yet, this has hardly begun, and it will certainly increase tremendously in the future. Our knowledge of life in the depths is extremely limited and even the species that inhabit coastal waters, which we have been able to classify as a result of netting and trawling, have only been observed in their natural habitat since the introduction of the aqualung. What this method of observation allows to be seen is of such interest that it has been suggested that a special enclosure for fish should

Opposite page: Of all creatures, insects seem the only ones that can successfully combat man. This is probably due to their prodigious faculties of adaption to diverse ecological and climatic conditions. This flexibility is well illustrated by tropical insects living on shrubs and bushes which imitate buds, twigs and grains.

In the upper part of the picture can be seen the posterior part of the abdomen of a membracide, resembling prickles and grain. (Photo Lod).

be established near Monaco, where biologists would be admitted only as observers. During the course of dives made near the Galapagos Islands, pupils of Konrad Lorenz and Nikolaas Tinbergen have secured amazing photographs and observations of fish behaviour; and 'villages' of octopuses have been discovered, where these creatures hide under stones which they have doubtless fetched for themselves; the entrance to these hide-outs is closed with a flat stone which the octopus holds in place with one of its tentacles when it does not want to be disturbed.

There is another biotope much closer to us, which is nevertheless quite strange, and this is life at the level of the tallest tree-tops. Bioclimatologists have shown that temperature and other climatic factors vary greatly between ground level and the height of a human being, which is the height at which observations are generally taken. An insect on the ground moves about in an overheated atmosphere where, however little the sun may shine, the temperature can easily reach 40°C to 50°C, even if human beings feel nothing more than pleasant warmth with a gentle breeze (at ground level winds are slowed down a great deal). Thus insects and human beings inhabit very different worlds. If the insect is a large one (a golden scarab, for example) it will find the climate much more temperate than will a tiny insect moving about very close to the ground. In fact, temperature falls very rapidly in the first few inches above ground level.

The little we know about life at the top of a tree fifty feet high tells us that differences are very much greater at this level. At these heights, winds blow much more violently than they do at our level, solar radiation is more prolonged and all climatic conditions are more extreme. Accordingly, the fauna inhabiting tree-tops is quite different from that at ground level: certain insects are only to be found at these heights (for example, the lovely rose-beetle *Potosia speciosissima*, which is only to be seen at ground level if it falls there by accident; entomologists consider it as a rare insect, whereas it is probably very common in its natural habitat). Birds also inhabit these levels. Research on life high in trees necessitates complicated and expensive scaffolding, which is why research on this subject is so limited.

Science's great problem is still to understand phenomena and, in the case of animal biology, to decide on the significance of the great plethora of animal species and types of behaviour amidst which man is almost submerged. One would need to be a zoologist or, still better, an entomologist, actually to

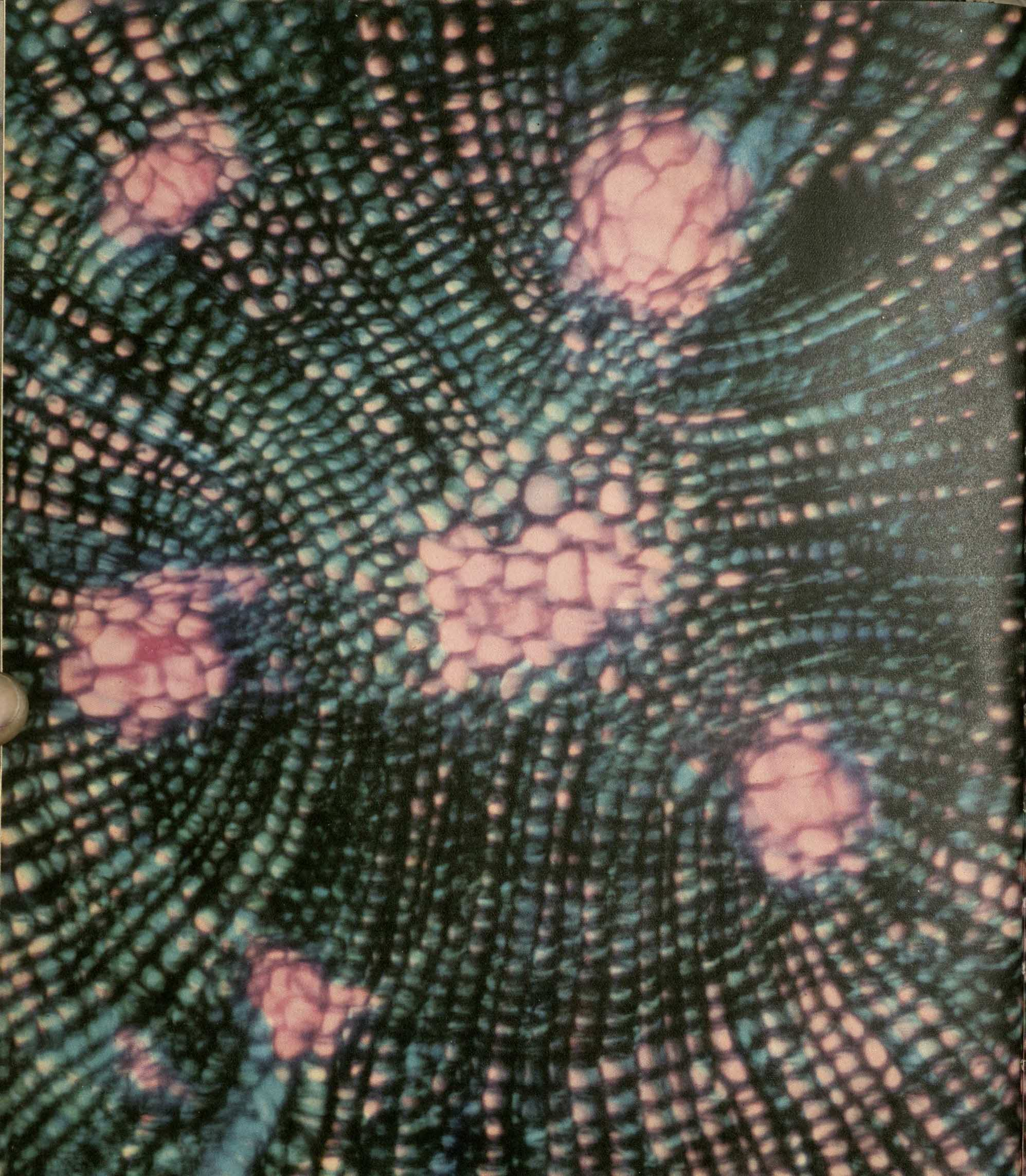
⁂

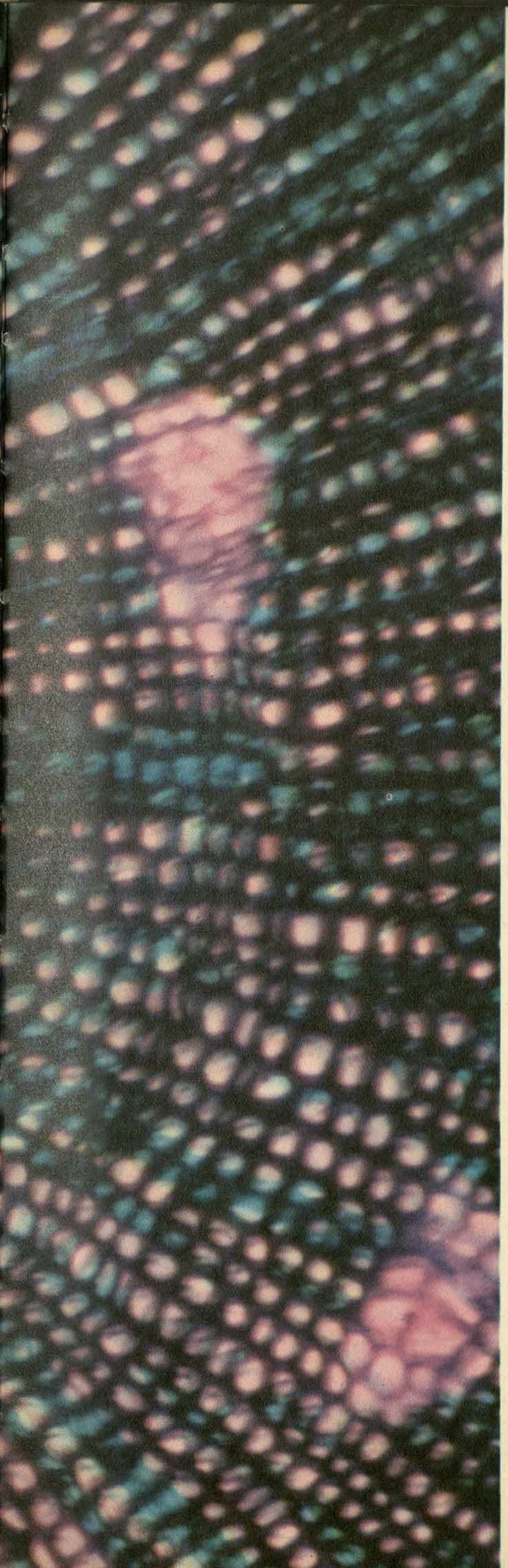
understand what I am trying to say. For example, in France alone there are more varieties of flies than there are mammals throughout the whole world. This is not a taxonomist's fantasy; most of these flies differ more from each other than a mouse differs from an elephant.

Eighty per cent of living creatures are insects; from the beginning they have had to overcome considerable handicaps because of their tiny size. They can have only very few brain cells and this prevents them from being as intelligent as larger animals; their equipment is not sufficiently elaborate. If you only have a pair of small pliers, you cannot build a calculating machine; you need many different parts which have to be put together. This is just what social insects have done. The concentration and juxtaposition of tiny individual brains (we begin to feel our way towards understanding how this takes place) results in the creation of a 'super-brain' far superior in performance to that of other insects. Thus they practise agriculture, and stock-breeding, and the art of war in order to obtain slaves. During the many years that I have studied large colonies of ants, I have often wondered why this process of 'civilization' came to a standstill. But perhaps it is still going on, perhaps it is only a matter of the relative speed of progress. Ants and bees are much older than we are; they existed forty million years ago, while we have a history only going back a million years. Human progress, however, has been made at breakneck speed, both on the intellectual and somatic levels; this speed has astonished palaeontologists. If ants have maintained their normal rate of evolution, it is perfectly possible that they are continuing to evolve beneath our eyes, though we see nothing because of the difference in rate. I sometimes amuse myself with the thought that in a hundred million years time (to a palaeontologist this would not seem very long) some librarian with compound eyes and rustling antennae will note that after prehistoric times a race of huge bipedal animals passed through time and space at the speed of lightning, and that it appears from remains of their tools and machinery recovered from geological strata that they were not wholly lacking in intelligence.

This may sound like nonsense, but we are badly equipped for understanding man's place in history because we cannot see it in context. We only know one planet, which is doubtless a special case and therefore we cannot generalize. We can only hope that one of the results of interplanetary flight will be the development of 'exobiology', as science fiction writers have already termed it.

⁂





Plant cells seen through the polariscope recall medieval stained glass, or an abstract composition. But their role is not simply aesthetic. As Pierre Chouard explains, what we learn from plants can be decisive for the future of mankind. (Photo Lod).

Plants in the future of man

Pierre CHOUARD

Man is closely associated with his environment and in contact with everything around him. Plants play a part in this close association, and have special importance for the future of man. This importance is greater than we may think: the plant world is an irreplaceable element for the future. What we learn to do with plants, as well as what we can learn about them, will be decisive factors in the future of mankind.

Plants and world hunger

What are the limits to world production from the point of view of the subsistence level? This is a problem which has become commonplace from repeated discussion. The answer to this question—or the solution of this problem—is essential for man's survival.

The most obvious link between man and plants is the necessity for food: plants provide man with his foodstuffs, either directly or by providing fodder for animals whose flesh we eat or whose milk we drink. Man is largely moulded by the conditions governing the production of the principal plant foodstuffs in different regions of the world: it used to be possible to speak of a corn civilization or of rice, millet, or maize civilizations. These, however, are things of the past.

Both-the present and the near future are overshadowed by a new situation, that of world hunger, one of the major problems of today. Populations are increasing much more rapidly than they used to because enough rudimentary hygiene has now percolated to even the most primitive peoples to ensure the elimination of the great epidemics of the past. The increase in food production does not match the population growth, or at least not in the semi-tropical and Far Eastern countries.

It is true that high productivity in certain temperate, technically advanced countries, and improved methods of transport, are such that the great famines of the past, which suddenly decimated certain countries like an epidemic, have practically disappeared. Nevertheless, there exists a permanent endemic condition of undernourishment and of nutrition insufficient both in quality and quantity. Much more than half the world's population probably suffers in this way—certainly more than one thousand million human beings. Can plants supply the needs resulting from present-day and future undernourishment?

This situation has been the subject of lasting international discussion. The most urgent necessity is to feed those who are starving: this is not the only problem, but it is the most urgent. We have to discover what are the limits of the capacity to produce foodstuffs by normal methods. These methods consist of plants acting as factories for the production of vegetable matter.[1] The technical aspects of the problem are these:

Plants are the only living beings known to be capable of turning large amounts of inorganic substances (water, air, and mineral salts) into complex organic matter which can be used as foods by men and animals. This ability is due to the plants' power of photosynthesis which allows them to capture part of the energy of the sun and by means of cells exposed to light, thanks to their green pigment called chlorophyll, to make use of this energy by transferring it to chemical systems which build up extremely complex organic molecules.

In the past, it was thought that the capacity to produce foodstuffs depended solely on the possession of fertile soil and traditional methods of cultivation, and because of this wars were fought for possession of fertile land. Today we know the true reasons for fertility; in other words, those factors that are really responsible for the productive capacity of plants.

First among these factors is sunlight, the source of energy for the vegetable machine, which, in contrast to mineral resources such as coal and petrol, is permanently capable of renewal. Coal and petrol deposits will be exhausted within a few generations, and even atomic energy is dependent on fissionable material such as uranium, which, though plentiful, cannot be relied upon indefinitely. Sunlight will still be available to us for millions of years to come, and other phenomena so far unsuspected may become available before the sun fails us.

As distinct from concentrated mineral resources, sunlight is dispersed at a low intensity per square metre (approximately one kW) and covers enormous areas. The solar energy dispersed over the temperate regions during a year amounts to a thousand times the energy now produced from coal throughout the world during the same period, and 500 to 800 times that of our total energy requirements. However, the energy from sunlight can only be captured by plants with low efficiency: approximately a thousandth of the solar energy dispersed over the total surface of a whole country. This rises to one or two per cent on well cultivated land when growth is at its height, and to between five and ten per cent in the most successful laboratory experiments. The margin between the average yield of the whole earth's surface and that of intensive cultivation, and thus, *a fortiori,* the possible yield in the laboratory is such that we are justified in being optimistic about the problem of famine. So far we are not at the end of our capacity to produce foodstuffs. This capacity far exceeds the requirements of the present situation, but greater efforts will certainly be necessary before these capacities are fully realized. There will be difficulties, but with perseverance and knowledge we should succeed.

Starting from the basis of the immense resources represented by solar energy for food production capacity, there are several other factors involved, as I shall show.

---

(1) *This question has been discussed in Volume III,* The World of Plants *(pages 19-30, 136-146, 156-158).*

Factors necessary for fertility

Temperature: Photosynthesis and plant growth can only take place within fairly limited ranges of temperature, which vary according to species: for instance, myriads of algae live in cold sea water, while others can exist in hot springs. The highest rates of food productivity are to be found in plants growing in temperate or warm climates, particularly those where the temperature undergoes considerable variation between day and night. Thus some deserts, such as the Sahara, are paradoxically the areas most capable of production because of their brilliant illumination and daily variation in temperature. Another factor is necessary, however: water.

Water: lack of water is usually the factor most often responsible for limiting the ability of plants to use light in the production of organic matter. The minimum amount of water necessary for the production of one gram of dry organic matter is between half a litre and one litre, flowing through the plant and disappearing into the atmosphere by means of transpiration. A supply of fresh water at the right periods and in quantities suitable for each kind of cultivation, is the key to really productive agriculture. It is therefore essential that research should proceed on methods of irrigation and of desalination of brackish water, so that arid and semi-arid countries may become fertile.

The amount of carbon dioxide present in the air: the factors responsible for maintaining the amount of carbon dioxide in the air in a ratio of 3 to 10,000 all over the world are these: the balance maintained between atmosphere and oceans; animals which breathe out carbon dioxide; plants which, in daylight, absorb carbon dioxide and turn it into oxygen; and winds which stir up the atmosphere. In full sunlight, the yield of usable products resulting from transformation of solar energy is diminished if there are insufficient quantities of carbon dioxide to supply the active cells. It is possible to counteract this insufficiency with additional carbon dioxide, 'CO_2 manure', but as this gas is highly diffusable, it is not practicable. It is possible that plant production capacity might be raised all over the world if there were to be an increase of carbon dioxide in the atmosphere, as has occurred during certain geological eras. Even now, by the burning of coal and petrol, and from cement factories which extract carbon dioxide from limestone, we are enriching the carbon dioxide in the earth's atmosphere probably at the rate of one hundredth every century. These are not simple matters, because if a greater increase in carbon dioxide were to occur we should have an atmosphere something like that of a greenhouse; the temperature would increase by several degrees, which could have the effect of melting the ice caps and raising sea level by many feet.

Fertilizers: soil that is naturally fertile provides the mineral elements essential to plant growth, and at the same time it provides colloids in granular form which ensure permeability for air and water as well as preventing fertilizing matter from excessive leaching by rain-water, while enabling plants to draw upon the materials vital to them—minerals, air, and water. These basic factors for soil fertility are used by agriculture in traditional ways or in ways perfected by scientific knowledge with a view to loosening the soil and replenishing its organic colloids (manure, straw-bedding, green-compost) as well as renewing mineral ingredients (suitable mineral fertilizers). Fertilizers essential to plants in large amounts are nitrogen in the form of ammonia or nitrates, phosphorus, in the form of phosphate, and potassium, and in smaller amounts, sulphur, magnesium, calcium (which are generally present in sufficient amounts in the soil itself) and other necessary traces of iron, copper, boron, zinc, manganese, chlorine, molybdenum, etc. Continual applications of soluble fertilizers can be a substitute for natural soil fertility by providing plant roots, on inert mineral substrates (such as sand or gravel) with solutions of fertilizers in sufficiently diluted form. Cultivation without soil, or hydroponic growth, is based upon this principle. This type of cultivation dispenses with real earth, but requires complex installations and constant supervision.

Opposite page: Sometimes scientific research seems to be very far from concrete reality. What connection can there be between this monocotyledon leaf, seen under a microscope, and the problem of world hunger? The continuous improvements which biological research has effected, and which will affect cultivation and agriculture will perhaps one day nourish humanity—thanks to cultivation without soil, hydroponic cultivation, and improvement of edible plants. On that day, the 'geography of hunger' will become part of history. (Photo Lod).

Finally, plant productivity depends on the plants themselves: different types inherit their rate of growth, ability or inability to adapt to certain climatic conditions, and the aptitude for certain processes of synthesis leading to production of foodstuffs of varying quality, etc. Genetic improvement of plants, experimental knowledge of their environmental needs, either from the point of view of selection or with the aim of creating suitable conditions for them, offer the most modern and economical basis for present-day cultivation, and especially for future progress in agricultural production of foodstuffs.

Will our food always come from plants?

We may well ask if plants now cultivated will always be our only source of foodstuff. We shall try to outline here some of the prospects suggested by recent research.

I. *Atomic energy:* With the immense resources of atomic energy at our disposal, starting with the extraction of coal or carbonates from limestone or even of hydrogen, from water, as well as oxygen and nitrogen from the air and other mineral substances, it should be possible, by using industrial synthesis, to manufacture certain simple chemical compounds, such as ethylene and ammonia, and gradually from this basis we might achieve synthesis of the complex organic molecules which constitute our foodstuffs. Success in synthesizing rubber or polymerized fibres such as nylon provides an encouraging example.

However, the cost of these synthetic products for industrial use is much higher than that of ordinary foodstuffs such as sugar or starch obtained from agricultural products. Also, as far as synthesis of molecules for *qualitatively* essential ingredients, such as amino acid and protein, are concerned, yield from industrial synthesis is so low and manufacture so expensive that the prospect outlined here must be regarded as belonging to the realm of science fiction. Moreover, in view of the extreme complexity of certain vitamins and of the numerous protective elements necessary to our diet, qualitatively indispensable for our food and subsistance, but produced in minimal quantities by the animal or vegetable sources of food, it is evident that such a project is still extremely hypothetical.

II. *Photosynthesis in vitro:* It is also permissible to assume that one day we shall discover the secret of plant photosynthesis. Such a discovery presupposes that we shall learn to imitate the molecular structure indispensable for transferring, with a suitable rate of yield, energy from light to the chemical systems which carry out organic synthesis. It would also be necessary to know how to reproduce those methods of synthesis that entail the intervention of a succession of enzymes, the action of which is distributed over the infra-microscopic cell particles, for which the complex structure of the plant is equally necessary.

Although such a success may be possible, this will not make it any less necessary for us to use sunlight as a permanent source of energy; as we have already seen, it is very widely diffused all over the surface of the earth, whence the consequent limitation in yield which would also affect our attempts to imitate nature artificially. If one day a food industry of this type should come into being, it will in many ways resemble present-day agriculture in being widely dispersed; it would not increase the capacity of world agriculture more than would rational irrigation of arid zones, where traditionally cultivated plants could then be grown.

III. *Other types of plants:* Another dream is that of sources of food other than 'plants', commonly so-called, with leaves, stems and roots which can be 'planted'. An example which springs immediately to mind is that of algae, particularly unicellular algae such as *Chlorella*, which have been cultivated successfully. This kind of vegetation is more suitable, however, as animal fodder than as succulent food for man. The cost per unit of foodstuff is at present higher than the cost of foodstuffs produced by traditional methods of agriculture or by simple hydroponic cultivation. As things are at present, cultivation of algae is a question of supplementary techniques which can be extremely valuable in certain limited cases. The prospects for extending this kind of cultivation would be greater if it were possible to eliminate the considerable loss of water which occurs when algae are cultivated in the open under strong sunlight, such as there is in arid zones, where, incidentally, water evaporation provides a convenient method of cooling. It would also be necessary to know how to cultivate types of algae resistant to higher temperatures. Such temperatures might be those of liquid media exposed to sunlight but without evaporation. High yields could also be obtained by cultivating marine algae in salt water, of which great quantities are permanently available. Such processes have not yet been discovered, but are certainly possible and could provide an important supplement to, though not a complete replacement for, normal foodstuff resources.

In conclusion, as far as our present knowledge goes, the only resources upon which we may rely in order to deal with the problem of world hunger are plants as we now know them, by taking into account all possible improvements in cultivation resulting from a complete understanding of the ecological and physiological requirements of plants, as well as their genetic capacities.

Possibilities of improving cultivation

Since mankind's basic necessity, food, depends upon the cultivation of plants, let us consider the most efficient methods for improving cultivation, as well as the limitations of such improvements.

Irrigation is probably the most spectacular of all these methods of progress. The effects of irrigation, which are already apparent in countries with temperate climates, are staggering in arid or semi-arid countries. Even so, it is necessary to pay very careful attention to the techniques of cultivation that involve irrigation.

An inadequate supply of fresh water is the first and inevitable obstacle to this powerful method of increasing the quantity of foodstuffs. It is possible to overcome local water scarcity fairly satisfactorily, and here we should mention the gigantic engineering projects that are changing the face of the earth, for instance, Russian projects in the steppes of Asia, which have contributed to food supplies. Similar solutions may be possible elsewhere, such as diversion of the abundant African and South-American equatorial waters northwards and southwards with the aim of irrigating subtropical deserts. It may also be possible one day to obtain fresh water by desalination of brackish or sea-water by distillation, electrical osmosis or other methods. It may even be possible to obtain fresh water supplies by refrigeration (for example, it is not absurd, though it may be premature, to imagine that icebergs might be transported to supply a fresh-water lake in order to irrigate part of the Sahara).

Nevertheless, using water in this kind of way will always be expensive. The future lies in using it economically by ensuring that the maximum plant-yield is obtained. Hydroponic cultivation has a part to play in this connection, provided that soluble fertilizers continue to be available.

Great progress has been made in improvements to grasslands and pasturage, with excellent results: grass, which grows all over the world and can be used as fodder, is the normal source of milk and meat production. Such lands yield little under ordinary conditions, but properly treated they can become a rich source of production. Even grasslands used successfully in the past have been considerably improved by modern methods, such as rational use of manure, selective weed killing, choice of high-yielding species of grass, methodical exploitation of pastures in rotation, etc. There is considerable room for more progress to be made in these methods throughout the world, but it is dependant upon a continuing supply of the necessary fertilizers.

All plant foodstuffs, of whatever kind—cereals, beets, sugar cane, vegetables, trees, medicinal plants—can benefit from progress in fundamental scientific research applied to each individual problem. The most successful methods of improvement are genetic selection, careful ecological adaptation to the surrounding environment, and suitable stimulation of growth and flowering. Such scientific techniques are beginning to benefit from the phytotron method, ie, experiments carried out in artificial climates carefully simulated and controlled. This method has given a great stimulus to agronomic research and enables scientists to approach the problems of growth and development from a better standpoint. Such research is one of the new factors in the future of agronomic progress.

All these developments are limited, however, not only by the amount of energy contained in sunlight, by maximum yield from photosynthesis, by the small amount of carbon dioxide in the atmosphere, by certain seasonally unfavourable temperatures, but above all—and this is more important than anything else—by supplies of water and fertilizers. As far as these two factors are concerned, we are not far from the limits of possibility and the limitation of the factors responsible for productivity in the world.

We have already discussed the problem of water. As far as fertilizers are concerned, the situation is different: because of synthesis making use of nitrogen from the air and of the atomic energy which will become available, nitrogen fertilizers will become almost unlimited. As far as potassium is concerned, the prospects are less hopeful, although potassium mines are still rich and abundant; and also, when they do become exhausted, potassium from the sea, though very dilute, will doubtless be extracted by means of the sources of energy which we shall then have at our disposal. There is a much greater shortage of phosphates: phosphate mines, although quite sufficient at present, will probably be the first to become exhausted. It will then be necessary carefully to collect bone and ash phosphates. Above all, intensive efforts will be necessary to concentrate phosphates which are dispersed in extremely low concentration in rocks or even as trace elements in the sea. The price of phosphates in this dispersed form will inevitably be high, which will be a limiting factor.

There are other limitations, or rather difficulties, which I can only mention here: the most formidable of these is the slowness with which technical progress is being passed on to the hundreds of millions of farmers scattered all over the world, above all, in those countries which still have to learn the rudiments of science and technology and where progress is confronted with deeply-rooted social prejudices.

Furthermore, intensive agricultural techniques require supplies of machinery, fertilizers, and equipment which are normally to be found only in countries where a prosperous and expanding economy exists. This constitutes a kind of vicious circle which can only be broken by simultaneous action at all points: a difficult undertaking. At the same time, temporary measures, such as gifts of foodstuffs, as well as investments, technical co-operation, and above all, education of every type, both for children and adults, must be applied. Nor must any impatience be shown at the slowness of progress.

Furthermore, in spite of the sound technical basis which justifies initial optimism, the fight against hunger is far from over. The natural and almost inevitable limits of plant productivity, although by no means yet reached all over the world, will nevertheless be attained one day, and will convulse mankind. The time will come (it has not yet arrived, but is only a few centuries distant) when it will be impossible for men to grow more. This will happen not only because the continents will be crowded with people, but also because adequate supplies of food will begin to fail beyond a limit which there will be no possibility of exceeding.

It is not possible to say at what point this limit will be enforced, though it is reasonable to guess that it will be when there is a world population of six to ten thousand million. This will not be in our lifetime, nor even in the twenty-first century, but it is a certainty within a few centuries, probably not more than three or four. Such an event will mean very significant changes for which humanity should gradually begin to prepare, although we ourselves shall not experience them.

Up to now, mankind has flourished by acting on the famous commandment, 'be fruitful and multiply'. We must, however, remember that the conclusion of the commandment is: 'and cover the surface of the earth.' In the past, this conclusion seemed lost in an unimaginable future; but now it can quite clearly be envisaged, if not as applying to ourselves, at least as applying to generations relatively close to our own.

It is not for a botanist to speculate on the future of the human race, but it is certain that the customs, habits, and even the idea which men have of the world and of life will be very different for those who will have mastered the universal stock and language of science and technology. At present, both these disciplines are impregnated with the idea of material progress, readily assimilable by humanity's tradition of expansion, but which will then be confronted with an imperative necessity for limitation of world population. This 'stationary condition', if it is not to result in appalling conflict, will require the acquisition of a wisdom which we are still far from having achieved. Some people see this occurring under the guise of evolution, others imagine it taking the form of apocalyptic events. This 'mutation' of humanity is nevertheless an inexorable necessity. Later in this discussion we shall mention another aspect of this change.

For the present, it will be sufficient to note two essential facts: (1) These enforced limitations do not apply to us today; generations still to come will have the task of pioneering this humanity of the not-too-distant future. (2) Since we are considering plants in relation to man, we should remember that to a large extent the future is governed by the rules of plant growth in relation to environmental resources.

Plants in relation to human activity

Let us return for a moment to our starting point, which was plants in relation to man today. Although the fight against hunger is the most obvious of the connections between humanity and the plant world, it is not the only one. There are others that concern both our physical and mental lives.

Plants and the industry of the future: chemical industry

In the past, agriculture (cultivation of plants and the animals that feed on them) supplied nearly all men's needs: food, of course, but also clothing (skins and cloth), various housing requirements (timber for beams), soaps, dyes and paints, and warmth (firewood). These resources even included energy and means of transport (cart-horses and other animals were fed on grain and fodder). Except for foodstuffs, nearly all these commodities have been drawn, since the advent of the industrial era (which coincided with the exploitation of coal, then of petrol, and finally of atomic energy) from mineral sources. These substances are either products that have been directly extracted, simply purified and processed in the usual way (metals, for example), or are synthetic products based on raw materials obtained from coal or oil, such as dyes, detergents, fibres, plastics, drugs, etc. Oil chemistry has taken the place of the agricultural chemistry of the past.

But the sources of coal and oil are inevitably diminishing, and although we possess atomic energy, we shall one day be very short of the many products based on oil derivatives. At present, these products derived from coal and oil (in the past built up by plants and animals without cost to us) are much less expensive than similar products supplied by agriculture, but this will not be the case if men are forced to resort to means of direct synthesis from water, air and calcium carbonate. Then, products which we do not at present want to draw from agriculture, will have to be supplied by it for industry and not for food. This exploitation of the cultivation of land is known as chemurgy. We can see some of its first fruits in some industrial syntheses, such as the production of man-made fibres for textiles, based on castor-oil plants instead of oil, petrol or coal.

At present, agriculture is of importance only as a market for the supply of food.[2] If, as has already occurred with the economies of most European countries, it can only supply countries that are solvent, that is, countries that are well equipped and modernized, such a market lacks flexibility: when immediate needs have been satisfied, it ceases to expand. This accounts for the agricultural stagnation which has affected all technically advanced countries for the last century.

Things will be different when sources of coal and oil are exhausted. Meanwhile, farmers will have reconstructed their own profession, for example, by adapting the size of their undertakings to the new conditions. Then agriculture, which will always remain the basic source of foodstuffs, will throughout the world gradually come to assume the role now played by oil and coal.

Plants as a setting of life

Industrial development is a necessity for the prosperity of humanity, but its workshops, smoke, pylons, and overcrowding are very ugly. Urbanization is a corollary of industrial development. The market towns of the past have given way to cities where men feel rootless. We have only to think of the huge working-class suburbs which have grown up in recent years, the great conurbations of today. Three-quarters, almost nine-tenths of humanity are threatened with being submerged by industry and urbanization.

Will it nevertheless be possible to reconstitute in industrial life something like the natural setting which rural life used to provide and which moulded men's minds and bodies? Attempts have been made to achieve this object with garden cities. Modern planning may tend still more towards huge areas of urbanization which nevertheless contain parks and even small areas of intensive agricultural cultivation together with patches of forest such as the enormous American 'megalopolis' which stretches from Boston to Washington and Pittsburgh. Similar areas are being planned in Europe. At the same time, there is a growing movement in favour of national parks for the protection of nature.

The very stress of life in modern cities leads their populations to return to plants as vital necessities—whether as lawns, trees, or flowers. The oxygen which these plants restore to us during the day, real as it is, is only the symbol of an even more important psychological event—that of renewed contact with the life of nature, with its marvels which are renewed season by season, its stability and endurance, and its beauty, so marvellously expressed by flowers, all of which exist in spite of the difficulties of our own lives.

Plants play yet another part in the life of man; their importance for humanity will increase in centuries to come.

---

(2) *Except for a few fields of secondary importance, and that of the production of pulp for paper which is in full development.*

Plants and the conquest of space

At last, man has ventured beyond the earth. Yesterday's science fiction is today's reality, and our fathers' prevision was no delusion.

We should not deceive ourselves, however. Although the planets and satellites of the solar system will one day become accessible to us, the stars are unattainable, or at least not by means which we can envisage at present. The speed of light cannot be exceeded, and even to come near it would require the expenditure of impossible amounts of energy. The time needed to reach the nearest star and to return would probably take more than a thousand years and such a prospect can only be called fantastic. It is therefore hardly likely that the conquest of space will break the limits imposed on our expansion over the surface of the earth: to colonize the moon, or even Mars and a few artificial satellites, will not change the order of magnitude of habitable earth surface; it will only increase it slightly.

This does not diminish the importance of such an amazing conquest, or the results that it may have on humanity's technical achievements. Nevertheless, it should be remembered that this venture, though apparently purely industrial and physico-chemical, can only take place with the assistance of plants.

It might be possible to survive for a few days with reserve foodstuffs and oxygen on some artificial satellite or in a capsule launched towards the moon. But it would be impossible to survive there for long, or to found a colony, without plants being included in the project.

From the earliest times up to the present, plants have had the function of restoring the earth's atmosphere by releasing oxygen into it. Without them, the ceaseless cycle of production of foodstuffs could not take place—the cycle which, while it makes demands upon our mineral reserves in the soil, otherwise uses only light as a source of energy.

Wherever there is sunlight in sufficient intensity for a positive balance of photosynthesis in relation to plant respiration, there also it is possible to envisage a human colony that could live in a state of perpetual autonomy without having to borrow from the earth's surface.

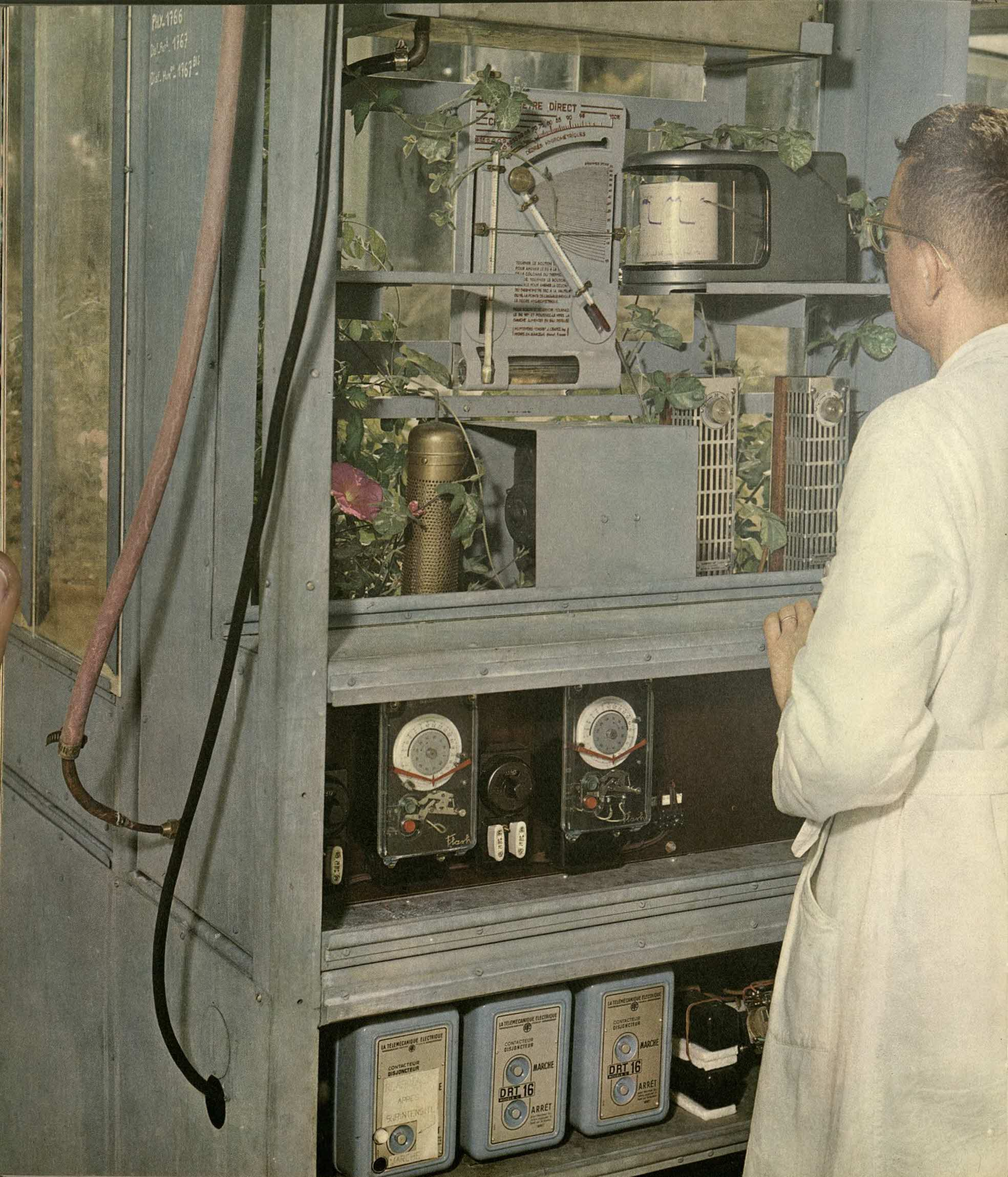
It would not be an easy matter to reconstruct artificially on a small scale the whole cycle as it takes place on earth, including plants, animals, an initial quantity of air, water, minerals, and an external supply of light, in order to create an autonomous biological unit in which plants would produce foodstuffs by eliminating waste matter. Nevertheless, the problem could be solved technically by using phytotrons.

Plants, which have played a part even in man's development of urban civilization, will have to be included in his ventures into space; even there plant life will be indispensable to him.

Plants and the growth of knowledge

To the extent to which man's spiritual life is more important than his physiological existence, and the joy of discovering, knowing and loving truth is the aim and distinguishing mark of humanity, it seems to me that it is worth while to define the part that plants have played in the growth of our knowledge of the world and of ourselves.

I am not speaking only of recent or even present-day botanical science, important and interesting though this is: I mean also the pleasure I experienced in my youth when I


Phy. 1766
Del. Sup. 1767
Del. Hum. 1767 Bis
TRE DIRECT
DEGRÉS HYGROMÉTRIQUES
Flash
LA TELEMECANIQUE ELECTRIQUE
CONTACTEUR
DISJONCTEUR
MARCHE
DRT 16
ARRÊT

became aware of the amazing diversity of flowers, in all their species and varieties, the way they could adapt themselves, their individuality, and the various mechanisms of plant life. These joys are precious to naturalists and to biologists. Those who are unaware of them, but have studied other realms of knowledge are human beings just as the naturalist is—it is not therefore solely of biology that I wish to speak, but of that science which in the evolution of knowledge will confer on plants the indispensable part that they will play in the spiritual growth of mankind in the future.

It is evident that men possess a basic means of acquiring knowledge, largely intuitive and certainly not scientific in a rational and experimental sense, but which reaches something close to reality in this world. Even if this 'reality' existed only in man, it would still belong to this world, since we ourselves are part of the world.

For example, we are aware of liberty, of responsibility, and through these, of our dignity. Thus we feel that we are men and not merely animals. Animals cling to life, exist and reproduce themselves by mechanisms that involve little or no consciousness. Man with his reflexive consciousness views life differently: to him the only reasons that make life worth living are those which raise him above animal level, man's ability to acquire knowledge, to love, to be worthy of freedom, even if this appears absurd. If at least something of this kind were not included, however faintly, among our reasons for survival, we should not consider life worth living, and suicide or a return to purely animal existence would be the result. For those who have religious experience, it is but an added dimension to this kind of knowledge and significance of human life.

However, another type of knowledge has been developing, progressing slowly at first, but of late much more rapidly. This knowledge is science, or, in other words, an approach to the world that is completely rational, even rationalistic. This approach is based on experimental repetition of phenomena and on the use of the instrument of mathematical logic in the presentation and extrapolation of this knowledge. By the very fact that it can be repeated, every advance in experimental science contains fruitful applications: techniques which at first were empirical set the first problems for experimental science, just as astronomical observation set the first problems for the newly-emergent mathematical disciplines. Today it is the experimental sciences that give rise to new techniques and nourish them. They are the source of the modern idea of technical progress and the most revolutionary ferment in our lives.

We must not deceive ourselves, however. At the present moment, experimental biology is still at a very early and vaguely defined stage: we can only unravel the insignificant links in life. Our attempts to develop psychological and social sciences and even to express them in mathematical terms are only crude parodies of the methods employed by physicists and chemists, because we are still ignorant of the deep unifying factors between the different sciences.

The living universe consists of a tangle of systems of amazingly diverse complexity which do not yield all their secrets at the same time. I do not even believe that we know sufficiently well what it really means for a 'being' and the fullness of his existence to have a certain degree of complexity compared to the sum of its constituent elements without their mutual relationship.

Chemistry consists of a series of physical entities; biology consists of an even more complex series of chemical entities; man himself and his mind are the product of one or several even higher levels of complexity.

It is generally held that profound knowledge of biology only progresses by reducing the vital functions, one by one, to chemical

Opposite page: It is in phytotrons, marvels of modern technology and perfect laboratories for the living world, that it is possible to study without any hindrance the perpetual growth of plants. It is by means of plants that we shall reach the decisive stage in experimental knowledge. (Photo Lod).

mechanisms. If only reduction is involved, we take life to pieces, but we cannot pretend to understand it as we are unaware of its workings, or in other words, of the higher kind of complex which would allow us to reconstruct life This barrier is gradually crumbling, but only by means of progressing step by step from the simple to the complex. Thus one of the 'secrets' of life, self-replication, has been mastered in part, or at least as far as its most basic aspects are concerned: in certain enzyme functions of microbes. Self-replication is expressed, represented and even formulated by the structure of nucleic acids and the sites that carry their information. This is the *ne plus ultra* of molecular biology, to the progress of which great research centres of the world have dedicated most of their resources.

This success points the way. The next stage will certainly develop over and above this molecular biology. In the future we will have to broach the analysis and the search for mathematical models of the vital phenomenon with the degree of complexity immediately above molecular biology, namely cell differentiation and organogenesis.

At this stage, microbes will be of no use, since they are unicellular and do not attain this level of complexity: plants or animals will have to be used.

Plants, however, remain throughout their lives as perpetual embryos; that is to say, they are continually capable of new organogenesis as well as of differentiation and de-differentiation. Animals, which are far superior by reason of their muscular and nervous systems, and man with his intelligence, only possess these capacities for differentiation, de-differentiation and organogenesis in a very temporary form, namely, at the embryonic stage.

Thus it seems to me that, during this rise in rational and experimental knowledge, it is through plants that we shall achieve the decisive stage that we must attack. Plants are the object of research which should render us essential and irreplaceable services; they should be able to provide us with the key to the mechanism of certain meaningful patterns which exist at a level of complexity hitherto untouched where we have everything to learn. The knowledge which we are beginning to acquire of these phenomena of differentiation and organogenesis, to some extent purely ecological, is only the indispensable prelude

⁂

to new methods of research which will take molecular biology as their point of departure, but which will be directed at that level of greater complexity which the plant can reveal.

Naturally, we do not know what this future branch of science holds in store for us, but we may be certain that in this field plants contain vital information which only they, or almost only they, are able to supply.

Animal functions will be examined and understood in their turn, and finally those of man up to and including the basis of the most complex factor of all, that of his mental life. Only then will the social sciences have earned the status of rational and experimental sciences. The humble world of plant life will have played its part in the evolution of knowledge and understanding.

Thus, we return to man himself, the axis and centre of this Encyclopaedia.

What will happen when these two types of knowledge confront each other within man himself—primitive and intuitive knowledge and the new rational and experimental knowledge, based on the use of the constantly adapted instrument of mathematics?

Personally, I do not think that this confrontation will bring about the destruction of man by internal conflict. The universe contains too many signs pointing to unity to allow us to think that the confrontation, within man, of two ways of thinking can conflict with one another and result in destruction. It is more likely that they will complement and illuminate each other and that in this light the sense of freedom and the sense of reason will reinforce each other. It seems to me that this increase of knowledge and understanding could perhaps be one of the essential requirements for man's acquisition of the wisdom imperative for the survival of the humanity we have envisaged, when it will realize the necessity for what I call, for want of a better expression, a 'stationary' state or stage. Why should this not result in a higher kind of satisfaction, a higher level of existence and yet another form of progress? We know that love, which unifies and exalts a human being, but which necessarily implies that the object of our love must first be known, will permit us to hope that we also shall be able to attain a higher level of happiness.

⁂

It is possible that a hundred million years hence some librarian with compound eyes and rustling antennae will note that after prehistoric times there existed a race of fairly intelligent biped animals who travelled through time and space at the speed of light.

In praise of the future

Herman GREGOIRE

Modern man has spread his knowledge through the world. Though only a small and short-lived particle of this planet, over the last hundred years he has started on a Herculean task of artificial changes, although he foresees neither the consequences nor the limits of this activity.

Paul Valéry

Prevision is not only condemned by the vanity of men of letters and the antagonism of the Church—and not so long ago it was unwise to come up against either of these—it is also condemned by the mistrust of scientists. And yet! . . .

It is with deep respect for verbal nuances that I quote the following words of Pascal: 'You would not seek me if you had not already found me.' These words encompass questions of faith, revelation, grace and every attitude of mind opposed to the strict discipline of experimental science. But what could the scientist look for if he did not begin by making a conjecture, if he did not first imagine, if he did not to some extent dream—on this borderland of dreams where future reality is fashioned?

Those words of Pascal describe with deep understanding a process familiar to the mind of the research worker. Virile man, creative man, transcends himself, transcends life and the universe, and strives with considerable success to fashion it in the likeness of his most fanciful dreams. If, at a decisive point in our evolution, we had not acquired this capacity for glimpsing the possible through the mists of our dreams, we should never have succeeded in evolving from monkeys. Man is a foolish animal who leaves no furrow behind him; instead, he extends into the future. It is because of this that civilizations have been established.

Gaston Berger has said that the dream is the opposite of the plan. This is an excellent axiom for the man of action because its basic principle is the tempering of boldness with prudence. But has Mankind become what it is by discriminating between reasonable schemes and unreasonable dreams? Is it not because we have wished for the moon that we are now on our way to it?

It is the marvel of our age that the dreamer has suddenly become instrumental in transforming his visions into facts. For millions of years, anticipation meant only the pursuit of illusion. The flying horse, Jonah's whale, the chariots of fire of the prophet of Israel, the great walls that crumbled at the sound of trumpets or rose up at the sound of the flute—these were nothing but fairy-tale embellishments with no reality except as feeble attempts to imitate the flight of birds.

Within the span of a single century, our own, all the old dreams have come true. In a few years they have progressed from their first mechanical falterings to the astonishing achievements of the present day. Aircraft break the sound barrier and fly across the seas unpiloted by human hands; satellites explore interstellar space; lead is changed into gold; radio, radar, television and telecommunications weave a network of information, measurement and organization; remote control commands and establishes man's sovereignty on earth.

Those visionaries who in earlier times acquired the use of the instrument of mathematics and the knowledge of a few laws of physics were able to give substance to their dreams. Archimedes, the first prince of Science, produced one astonishing invention after another, as though the process were a game. He devised the endless screw. He astounded the world by inventing the lever. He counted the grains of sand of the universe. He projected a 'death-ray' on to the enemy fleet, his war machines seized their galleys in a super-human grip and sank them in the Bay of Syracuse.

So much for the physical world. It is too long since man invented the tool for him still to be astonished by the power it gives him. But was it originally a more preposterous dream, more contrary to nature or the natural order of things, than to wish to change our mortal condition? Be that as it may, the average longevity of man has doubled, our expectation of life has already exceeded the threescore years numbered in the Bible, and the myth of Methuselah is encompassed in the biologist's microscope. Death has been cheated, if not vanquished. Man has made his first leap beyond the biosphere into those regions where no form of life exists and has returned safe and sound.

A fabulous record! A wonderful achievement!

What link is missing in the chain between the legendary dreamer, the primitive teller of tales and the modern scientist? In practice, every scientist is gifted with prevision in proportion to his talents. If he were to make no conjectures about the future, how could he recognize it when it arrives?

It is by a process in which imagination takes the place of experience that the world has become the creation of scientists. If the scientist was long considered as an absent-minded visionary, this was because dreams formed a large part of his adventure.

Now he is a prisoner of his methods. Convinced that he cannot make something out of nothing, he refuses to deduce anything without verification, he never extrapolates without taking precautions, his conclusions are only provisional and based only on proven facts.

But Mankind has taken up the scientist's dream, and still asks him the eternal questions that spring from 'the restless spirit within us which ceaselessly asks: Who? What? Where? When? Why? How? and which compares past with present, future with past, possibilities with facts, fantasy with reality'. So said the poet Valéry. At present, any argument about prevision is merely an echo of the greater dialogue between restless mankind and the world of science.

Would it offend scientists to be compared with football-players? To the extent that prevision is an attitude of mind, a vision of the world transcended by the magnitude of the future, men in action are influenced by it to display a certain physical behaviour commensurate with this vision.

Football-players are for the most part average players who put their strength and endurance to the test during the game. They are carried along by events and are glad to remain where something has happened. But the star player is already elsewhere: some reasoned foresight has taken him on to that part of the field where the next phase of the game will be played. When the ball gets there, he is already on the spot to intercept it in that fraction of a second which represents eternity.

The scientist obeys the same demands of the near future when, under pressure from mankind's insistent demands, he turns his attention to the fields where the destiny of man is shaped.

In the language of sport, prevision simply means positioning, and equally, when an expert anticipates something, he is merely choosing the field in which he wishes to work and, especially if he is a doctor, to fight.

The purpose of his mission has transformed the man of science into the man of action. He is one of the craftsmen of the future. The scales which measure the significance of science must be weighted on the side of the future. Mankind may well ask whether it is still capable of producing great men and whether those of today can bear comparison with the great men of history. Ninety per cent of the greatest scientists of all ages are alive today and none of their prestige has been lost.

Where shall we find the perfect example of the man of action, the dreamer who transformed his dream into reality? In China? For millions of years China cherished the dream of immobility. It is from a German doctrine and Western discoveries that she looks today for the impetus wherewith to break through her formidable shell. In India? The pursuit of action is there contradicted by Nirvana, as it was in China by wisdom and throughout Islam by Mohammedan fatalism.

It is the European, the man of our own civilization, the man whose techniques have changed the face of the globe, who looks on the present as the spring-board to the future. The scientific mind is his distinctive characteristic. The period of his flowering extends from Newton to Einstein, from William Harvey and Claude Bernard to Pavlov. He has made progress his watchword. He has split time into infinite parts. Why should he consider the millionth part of a second except as a leap forward into the future? The future is his domain. He is the 'bird in inverse flight' spoken of by Apollinaire:

Bird in inverse flight, nesting on the wing,
On the fringe of our world's dazzling light,
Close your second eyelid,
For the earth will dazzle you.

He can establish extraterrestrial bases. He is about to make another dream come true: from the heights of Sirius he will look down on the earth in order to know and re-fashion it better. In this he is like no dreamer of the past.

Such an attitude of mind can be criticized or condemned. But it is to this very way of looking at things that we owe the wonders that have been achieved in our day. In Greece, in New England, in the Urals, wherever Europeans have settled, the impossible has become possible and the possible a daily reality.

The heir to the Greeks and the Romans believes that the future begins with the present, and in order to waste no time in vain prophecies, he himself prophesies. The capacity he has for shaping his own destiny springs, indeed, from an amazing ability to conceive an ideal picture of himself together with an attempt to live up to it. He 'opposes what is because of his concern with what is not'.

Is he wrong? Is he right? Many philosophers, and that passive attitude of mind which can easily be mistaken for wisdom, say he is wrong. All the peoples of the world say that he is right, and align themselves with him.

Even now, when so many things are in danger, he continues to create and to project an ideal image of himself; and this image, which becomes more and more clearly defined as science provides fresh basic data and suggests new possibilities, is what man demands that biology shall bring about for him.

In this work, the debate between mankind and science, to which I referred earlier, was opened by Jean Rostand, who, like

Socrates, asked the questions. Each of the eminent specialists who have collaborated in this work has answered him. It is neither my task nor my intention to intervene in the debate. On November 21, 1960, I was present at the first meeting at which our scientific advisers put forward their points of view on this momentous project. I saw these scientists behave in exactly the same way as the great champions of sport whom I cited as examples: they abandoned the unproductive ground where continued argument was fruitless and disputation confused, and moved away to that exact point where the urgency of the question and their knowledge of the subject most required them to be.

The choice of subjects discussed in this volume thus corresponds to the scope of biology and to the basic researches from which will come the fulfilment of a plan which, although not official, will nevertheless build the future: genetic control, grafts, embryo cultures, solar energy, artificial photosynthesis, minute knowledge of the cell.

For a plan there certainly is. There are also dues to be paid. Mankind knows that the scientist who has given him the atomic bomb and prophylactics is in control and that he can include the near future in his calculations. The doubtful gift of prophecy has been superseded. Its place has been taken by scientific prevision. This is founded on the rational use of a few fundamental arithmetical principles.

When a nation complains that it is not properly governed, it means that the ignorant men in office, instead of having a plan based on a few relatively simple mathematical truths, have allowed themselves to be overtaken by events.

The whole of mankind testifies by its revolutions, protests, declarations and all the evidence of its wretchedness, as well as by its hopes, that it will no longer allow itself to be overwhelmed by events. Humanity demands that those who lead it should have a plan. One of the strangest phenomena in this age of ours is that such a plan exists. It is founded, whether explicitly or implicitly, chiefly on biological discovery. Men who suffer from disease, who endure hunger or fear death or suffer from their own excesses, demand that science should stand by its promises. Scientists have been too cautious to make any promises on behalf of science. But they work to keep them as though they had made them, and for better or worse they are dedicated to them.

We could not end this important work on biology without mentioning the perspectives and sometimes the contradictions of a situation without precedent in history. It is a situation that creates new relationships between one type of man and the rest of mankind. It makes the scientist responsible for those achievements, good or bad, which until our time had been the province of Nature . . . or God. It wrests the scientist from fanciful conjecture and unfounded theorizing, and binds him to tasks which will ensure the future.

This is why I have endeavoured to define prevision; it does not mean acceptance of unproven facts, or the demarcation of man's destiny. It is rather the ability to envisage the future, to draw up an inventory of possibilities, and to make apparent the unknown. Prevision is the corner-stone of practical European philosophy, and what I have said about it is applicable to all the works which the Editors of this Encyclopaedia have dedicated to our present-day world.

In the past century, as Paul Valéry has said, man embarked upon a vast project of artificial changes, of which he can foresee neither the end nor the consequences. This plant, which was fertilized and which germinated, grew and bloomed in a completely synthetic environment, is surely the most beautiful symbol of this work.

⁂

Dictionary of biological and medical terms

In concluding this work, which is devoted to the biological sciences seen in their relation to each other, the publishers consider that a recapitulation of the subjects dealt with in all eight volumes is indispensable to the reader.

This recapitulation has been conceived in the form of a glossary to which the reader can refer whenever he wishes to enquire into any subject, term or idea, either in one of these volumes or in some other work. Clearly, a glossary of this kind could never be complete: the biological sciences are now in full spate and their vocabulary increases all the time. Nevertheless, every effort has been made not to omit a single word whose significance might puzzle the reader in his efforts to understand all the phenomena of life; several of the terms that are explained are not yet to be found in any dictionary and are not even used in any of the two hundred chapters of THE LIVING UNIVERSE. Most of them have, however, been used by various authors: and in these cases the explanation is followed by the number of the volume and of the page where the term is mentioned.

The glossary may also be considered as an aid to study; the two thousand words which it comprises are written in a concise and strictly scientific manner: the key words are shown in small bold type. Where the letters *mi* appear after a definition, the reader can refer to the marginal illustration which will facilitate his understanding.

Following the glossary itself there will be found a list of historical dates, highly important in their relation to a variety of the principal biological and medical problems.

I should here like to thank all the people who have helped me to produce this remarkable and unique work; in particular Madame Pernette Danysz, who has written lengthy explanations and edited many of the others; also Mlle Nicole Jauffret and Messieurs Claude Gaignebet and Dominique Ballif. I am grateful also to the scientific directors of THE LIVING UNIVERSE, who have ensured the accuracy of all definitions of microbiology, medicine, human physiology and embryology, in short to Albert Delaunay, Claude Jacquillat, Paul Laget and Philippe Sengel.

Paul Alexandre

⁂

A

Abiotic environment: a physical or chemical environment that is considered independently of the living beings in it. III, 114, 116.

Ablation: removal of part of a tissue or an organ affected by a pathological lesion. VII, 11, 35, 104-110, 138.

Aboral pore: in the fresh-water hydra, a small opening in the middle of the peduncle or foot attached to the support. I, 109.

Abyssal fauna: peculiarities of form of animals adapted to conditions of life at great depths. II, 56.

Abyssal waters: ocean depths that may reach ten km. II, 55, 56.

ACD solution: **a**cid **c**itrate **d**extrose solution in which blood is placed for storage in a refrigerator (40°C for two to three weeks) before being used for transfusions. VII, 53.

Acetobacter: acetic bacteria. These aerobic bacteria oxidize alcohol to acetic acid. *Acetobacter aceti* is used in the production of vinegar. IV, 147.

Acetone body: the name given to certain substances (acetone and diacetic acid) derived from the degradation of sugars and fats. In a healthy person these bodies, (nearly all acids) are normally destroyed, but not in diabetics (in whom they cause acidosis) afterwards appearing in the urine. VII, 14.

Acetylcholine: a chemical mediator liberated from some nerve endings. It is of great importance in the transmission of nerve impulses between nerve cells (synapses), especially at the neuromuscular junction. It consists of the acetic ester of choline and is destroyed by a specific enzyme, cholinesterase. V, 66, 67, 92; VI, 50, 54; VII, 60.

Achromatic spindle: see Cell division.

Acicular foliate: leaves in the form of needles (eg, those of pines). III, 121, 123.

Acid, amino, ascorbic, folic, lactic, muramic, nicotinic, nucleic, paraminopuric, phosophtungstic, pyruvic: see each under its alphabetical entry.

Acidosis: acid impregnation of tissues observed during certain disorders, characterized chemically by an increase in urinary acid and a lowering of the alkaline reserve of the blood (slight lowering of pH). Acidosis is shown clinically by the same signs as those of diabetic coma (deep coma). Two forms may be distinguished, a gaseous acidosis caused by an increase of carbon dioxide (due to diminution of lung ventilation) and a fixed acidosis produced by a diminution of bicarbonates (diabetic acidosis). VII, 51.

Acoelomates: animals without a coelon, that is to say, a body cavity. I, 88.

ACTH: adreno-cortico-trophic hormone; this is synonymous with corticostimuline, a hormone secreted by the anterior pituitary, which causes excitation of the secretion of the cortical zone of the adrenal capsule. ACTH is used in the treatment of allergic disorders. VII, 68, 69, 100.

Actine: a muscle protein present as filaments in the muscle. It combines with myosine and forms actomyosine. V, 127, 128, 146.

Actinic: a type of radiation that causes a physical, chemical, or physiological action (ultra-violet rays and solar radiation). VII, 149.

Actinomycete: a fungus of the schizomycete family and of the actinomycete order. *Actinomyces bovis* causes actinomycosis in cattle, which may sometimes be transmitted to man. III, 68; VII, 84; mi.

Actinomycin: an antibiotic used in the treatment of cancer because of its antimitotic properties, ie, it hinders the proliferation of cells and prevents their division. VII, 91.

Action potential: the difference of potential that exists between the inside and the outside of a nerve or muscle cell when subjected to excitation. A sudden depolarization is produced and the difference of potential moves towards zero. Action potential is very short, lasting approximately about a hundredth of a second. V, 63.

Actomyosin: a protein formed by the combination of myosin and actine, constituents of muscle fibril. I, 154, 155; V, 128.

Addison's disease: described by Addison in 1885, it consists of slow suprarenal insufficiency with melanodermia. Clinically it is characterized by the association of physical asthenia, which is clearly marked on repetition of psychological and genital effort, with hypotension, melanodermia, digestive disturbances, and loss of weight. It is usually due to tuberculosis of the suprarenal glands and sometimes to a contraction of the cortico-suprarenal, either primarily or secondarily due to poisoning. V, 52, 54; VI, 102.

Adelphogamy: in botany this describes the fusion of two 'brother-nuclei', that is, resulting from the same mitosis. This mechanism is widespread in fungi. III, 60.

Adenitis: inflammation of a lymph node. VI, 19.

Adenopathy: the name given to any disease affecting nodes, especially lymph nodes (eg, Hodgkin's disease). VII, 34.

ADP: adenosine-diphosphate, a chemical compound that plays an important part in muscular contraction. ADP is derived from the hydrolysis of ATP by adenosine-transphosphatase. This reaction frees energy (ATP → ADP + P + energy). ATP is then reconstituted by the addition of a phosphagen molecule. In this way an ATP molecule and creatine are obtained. I, 46, 47, 64, 155; III, 26, 27; V, 127.

Adrenal: internal secretion gland on the kidneys, formed from two parts that are embryologically distinct: the adrenal medulla, which secretes adrenalin (a vasoconstrictor hormone), and the adrenal cortex which secretes, besides androgens, two groups of hormones: the mineral adrenocortical (aldosterone) and the corticosteroids (cortisone). II, 71, 72; V, 48; VI, 101, 102, 103, 106, 120, 149, 150; VII, 105.

Adrenal cortex: an endocrine gland, the peripheral part of the adrenal gland. It secretes three kinds of hormones, the mineral adrenocortical hormone (aldosterone), the corticosteroid hormones (cortisone) and the androgen hormones. V, 23, 52, 54, 59, 137, 147; VI, 57, 90, 91, 98, 99.

Adrenalectomy: removal of the adrenal glands. II, 73; VII, 94, 130.

Adrenalin: a hormone derived from tyrosine, secreted by the adrenal medulla; it functions in stress phenomena. Adrenalin is the chemical mediator of the nerve-endings of the sympathetic nervous system. V, 52, 54, 83, 92, 94, 146; VI, 54, 90, 96, 102, 106.

Aedes aegypti: a mosquito of the *Culcidae* family, inhabiting tropical regions, which transmits yellow fever and dengue. VI, 19; VII, 75.

Aerial plankton: a mass of invertebrates, especially insects, which are to be found in large numbers in the atmosphere up to 4,500-6,000 feet. II, 54, 55.

Aerobic: the requirement of organisms for which oxygen is essential in order to live. The opposite to anaerobic. IV, 44.

Aetiology: the study of the causes of disease. VI, 35, 106, 116-118, 120, 126, 153; VII, 46, 47.

Agar: see Gelose.

Agglutination: the formation of a clump from particles previously dispersed in a liquid. (1) Agglutination of bacteria: a collection of bacterial cells forming clumps or granules visible to the naked eye and caused by the action of specific antibodies on bacterial antigens. (2) Agglutination of blood platelets, occurring in the first phase of the formation of a haemostatic clot (hyaline thrombus) after a vessel lesion. (3) Agglutination of red cells: a very important phenomenon, the study of which has led to the discovery of blood groups. IV, 17, 55, 58, 129; V, 34, 38.

Agglutinin: antibodies causing the agglutination of antigen particles. Agglutinins cannot co-exist in the blood with the corresponding agglutinogens without causing agglutination. V, 38, 39; VI, 43.

Agglutinogen: an antigen contained in the red cells that causes agglutination in the presence of the corresponding agglutinin contained in serum (see Blood groups). V, 38, 39.

Agrobacter tumefaciens: a bacterium that causes tumours in plants. III, 36, 69; IV, 60, 104.

Albuginea: a fibrous covering of the testis. I, 150.

Albumen: a type of reserve tissue in certain seeds. III, 13, 66.

Albumin: a simple protein of low molecular weight which is found in nearly all animal and vegetable tissues and has the property of being soluble in water. It exists in the circulating blood of higher vertebrates and is then called seralbumin. In some pathological conditions albumin is filtered by the kidneys and passes into the urine; the detection of albumin in urine assists the diagnosis of certain diseases. VII, 14, 26, 28, 53.

Albuminuria: a pathological condition characterized by the presence of albumin in the urine. VI, 93.

Alcohol: a chemical compound formed by an R radical and an alcohol function. Ethyl alcohol: a chemical substance derived from the fermentation of glucose and present in numerous beverages. Excessive alcohol drinking (alcoholism) leads to a number of metabolic disturbances (cirrhosis and anaemia) or psychological disturbances (delirium tremens). VI, 14, 15, 72-75.

Aldosterone: a corticosteroid hormone of the adrenal cortex. Its secretion regulates ionic equilibrium (Na^+ and K^+). It also adjusts the water balance of the body. V, 23, 46, 52, 54, 147; VI, 102.

Algae: chlorophyll plants of the Thallophyta group. Algae are frequently used as laboratory material, for instance, in the study of photosynthesis. The industrial cultivation of algae (chlorellae in Japan) or their collection (in Africa) may lead to a solution of the problem of the future feeding of populations. I, 20; III, 10, 19, 23-29, 46-49, 56-58, 140.

Alkaloid: an organic substance of complex composition present in plants. Alkaloids are physiologically active. Examples: caffeine, morphine, nicotine, quinine, and strychnine. III, 16, 153.

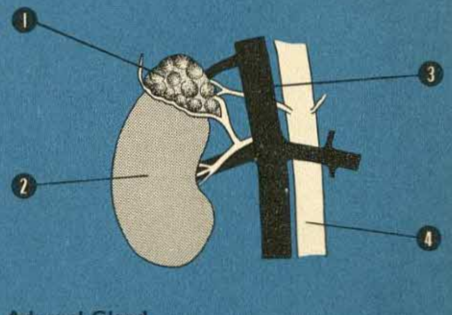
Alkalosis: augmentation of the alkaline reserves of the blood. V, 150.

Alkylation: a general type of reaction in organic chemistry, used in laboratories to transfer one hydrocarbon group or substituted hydrocarbon group from one molecule to another. VII, 81, 99, 101.

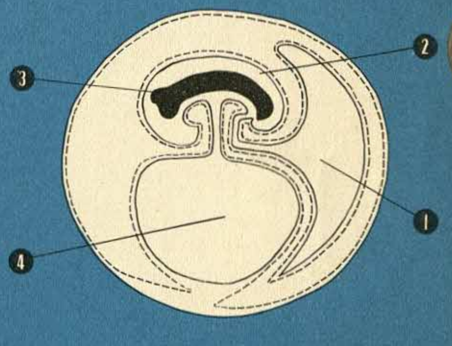
Allantoic membrane: an embryonic outgrowth of the posterior intestine, shaped like a sac. It has an excretory and respiratory function. I, 32; mi.

Allele: the gene corresponding to a given gene in the homologous chromosome. A gene may occur in two or more different forms. One of these forms corresponds to the normal gene, the others represent mutant genes: these are called alleles of the normal gene. I, 115.

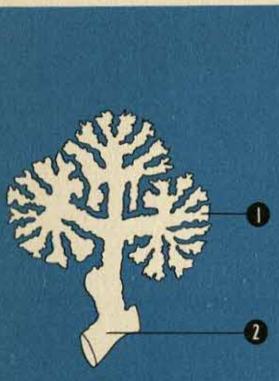
Actinomyces



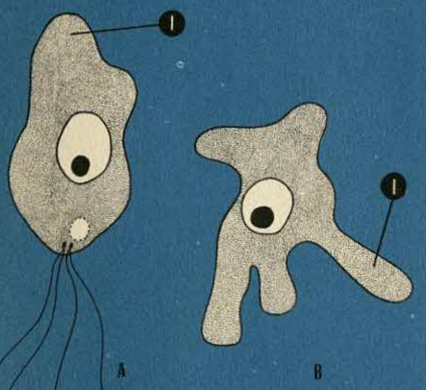
Adrenal Gland
1. Adrenal gland. 2. Kidney. 3. Vena cava. 4. Aorta.



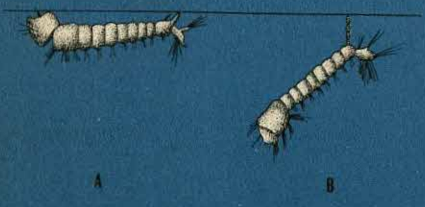
Allantoic membrane
Embryonic chick membrane. 1. Allantois. 2. Amnion. 3. Embryo. 4. Yolk sac.



Alveolus (lung)
1. Alveolus. 2. Bronchiole.



Amoeba
A. Flagellate amoeba. B. Parasitic amoeba.
1. Pseudopodium.



Anopheles (larva)
Comparison of position of the anopheles (A) and that of another species (B).

Allergen: an antigen, the penetration of which into the organism causes a reaction known as an allergy. VI, 52, 53, 55, 56; VII, 67, 71, 85.

Allergy: see Hypersensitivity. IV, 112, 115, 136.

Allogamy: pollination of flower stigmas by pollen from another flower. III, 130, 131.

Alpha rhythm: an electroencephalogram wave registered specifically from the occipital regions of the brain. It shows as a series of fairly regular oscillations of 8 to 12 cycles per second with periodic fluctuations of amplitude, giving it a 'spindle' aspect that is very characteristic. It only registers when one is awake but inattentive and with one's eyes shut. V, 71, 72, 74, 76, 78.

Alternation of generations: a succession of two generations, of which one is asexual and the other sexual. This alternation is sometimes found in animals, but more especially in plants. Among the ferns, for example, the haploid gametophyte alternates with the diploid sporophyte. III, 17, 57.

Alveolus, lung: a small terminal dilation of an alveolar passage. It is in the wall of the alveolus, which is very thin and elastic, that respiratory exchanges take place. V, 13, 14, 15, 18, 19; VI, 59, 60; VII, 24, 51; mi.

Amblyopa: reduced visual acuity in an eye. VI, 141.

Amblystoma: a newt-like amphibian of the Amblystomidae family. *Amblystoma tigrinum*, the tiger salamander, native of southern North America (Mexico and California). The amblystoma is the adult form of the axolotl. I, 113, 148; II, 37.

Amino acid: a fundamental constituent of living matter and protein. Examples: glycocol, valine, alanine, serine, etc. I, 22, 38, 39, 50; IV, 25, 26, 54, 58, 68.

Amnion: a fine double muscular membrane that covers the embryo of some invertebrates, and of reptiles, bird's and mammals. In vertebrates it is derived from the somatopleur. Its main role is to ensure the protection of the embryo against mechanical shock. I, 143.

Amniotic fluid: a liquid contained in the amniotic cavity of the amnion, in which the embryo lies. I, 143.

Amoeba: a unicellular animal of the rhizopod class; it has pseudopods that serve both for locomotion and phagocytosis. Certain species of amoeba are parasites in human intestine and are pathogenic: for example, the dysentery amoeba, which propagates by means of cysts and causes amoebic dysentery, which occurs mainly in warm countries, both in acute and chronic form. I, 56, 86; II, 12, 13; mi.

Amoeboid: the property of a cell to displace itself and feed in the manner of amoebas, that is, by putting out pseudopods. I, 86.

Amphetamine: a drug that excites the central nervous system and increases physical and psychological activity. VII, 56.

Amphibia: a class of vertebrates with lungs; they are oviparous, poikilothermous, have an undivided heart-ventricle and mesonephric kidneys. They grow from a larval to an adult state by a process of metamorphosis. They are divided into three orders (Urodela, Anura and Apoda). The order of Anura (frog, toad, etc.) is characterized by the absence of a tail in the adults. I, 152; II, 16, 120.

Amphioxus: the lancelet, an animal that lives on sandy beaches of the Mediterranean. *Amphioxus* occupies an important place in animal classification. It belongs to the order Protochordato, between the invertebrates and the vertebrates. It has a dorsal nerve cord, but no jaws. I, 19; mi.

Amygdalae: see Tonsils.

Amylase: enzyme whose role is to degrade the starch molecule to more simple sugars. Saliva contains amylase which is secreted by the salivary glands. VI, II; V, 50.

Anabiosis: a revival after an interruption of vital functions. II, 59.

Anabolism: constructive metabolism. It includes all processes in which simple chemical substances are transformed by the organism into more complex substances eg, protein). I, 39; V, 55, 140; VII, 62.

Anaemia: a syndrome common to numerous diseases characterized by impoverishment of the blood in haemoglobin and consequently a diminution in the total quantity of oxygen transported to the tissues and organs. The causes of anaemias are various: there may be a diminution in the number of red cells without the amount of haemoglobin per cell being modified (normochromic anaemia); in some cases it is even increased (hyperchromic anaemia). There may also be a diminution in the level of haemoglobin in the red cells, their total number remaining the same (hypochromic anaemia). In pernicious anaemia there is a concomitant diminution in the number of red cells and in the level of haemoglobin. A determining cause of the disease is the absence of a substance normally secreted by the cells of the stomach: the intrinsic factor, without which vitamin B_{12} (essential to the maturation of red cells in bone marrow) cannot be absorbed by the organism. Hyperchromic pernicious anaemia caused by *Bothriocephalus* (fish tapeworm) is also due to a deficiency of vitamin B_{12}. These anaemias can now be cured by treatment with intrinsic factor and vitamin B_{12}. Hypochromic anaemias, on the other hand, whether they are due to hookworm infection, to dietary deficiency or are 'essential', are caused by a deficiency of iron in the blood. Haemolytic jaundice is caused by a congenital anomaly in the maturation of red cells. Abnormal red cells produced by the bone marrow are immediately destroyed by the spleen, and there is therefore a notable diminution in the number of red cells. Haemolytic anaemias are diseases due to hereditary anomalies: they are caused by the presence of an abnormal haemoglobin, either the persistence of foetal B haemoglobin, as in thalassaemia, or haemoglobin S in the case of drepanocytosis. Haemolytic anaemia of the new-born (normochromic anaemia) is caused by an incompatibility between the blood groups of the foetus and the mother. The mother, in whom the rhesus factor is different from that of her baby, manufactures antibodies that destroy the red cells of the baby. The only treatment, in cases that are not too serious, is blood transfusion. VI, 43, 71, 78-82, 88, 102, 132, 133, 139; VII, 31, 96, 97, 99, 101.

Anaerobic: living without oxygen. To some microbes, oxygen is a true poison; these are the anaerobic microbes (tetanus bacillus and the septic vibrio). III, 29; IV, 19, 44, 52, 74, 77.

Anaesthesia: suppression of the sensitivity of an organism, or part of it, by means of chemical substances acting on the nervous system; eg, ether, nitrous oxide, chloroform, etc. VI, 10; VII, 49, 56-58, 63, 64, 108, 124, H.

Anaesthesiology: the study of artificial anaesthesia and its applications in medicine and surgery. VII, 54.

Analogous organs: organs of different kinds that fulfil identical functions; eg, a tendril that can act as a leaf or as a root. III, 51.

Anamnestic reaction: an immunological reaction. It is produced when an organism vaccinated a long time ago suddenly starts secreting a new quantity of antibodies. This generally occurs after a 'shock' and is a defensive reaction. It is called anamnestic because what happens occurs as if the organism had 'remembered' having been vaccinated. IV, 130.

Anaphase: the third phase of mitosis. This phase is characterized by the movement of the chromosomes towards the poles of the achromatic spindle. I, 62, 64.

Anaphylactic shock: shock that occurs after injection of a therapeutic serum, such as diphtheria serum or tetanus serum. It may also occur after the injection of an allergen or of certain drugs, eg, penicillin or procaine, or after a wasp- or bee-sting in a sensitized person. It occurs in the few minutes that follow the injection and results in a state of syncope with cardiovascular collapse. In this condition death may ensue. IV, 136, 137, 138; VI, 50, 53; VII, 68.

Anaplasia: a process in which certain cancerous cells lose some of their characteristic without being able to return to their original state; eg, in an anaplastic tumour of the thyroid, the cells of the tumour are incapable of fixing radioactive iodine. VII, 94, 96.

Anatoxin: see Toxoid.

Androecium: the male portion of a flower, formed by the stamens. III, 64.

Androgen: a chemical substance that exerts masculinizing effects in animals. There are many androgens, testosterone, produced by the testes, being the best known of these compounds. Its primary function is to induce and maintain secondary sexual characters in males. II, 84, 85; V, 54, 55, 57, 59, 137; VI, 102.

Androsterone: a hormone of the adrenal cortex which regulates a certain number of secondary sexual characteristics in the male, eg, hairiness. V, 52, 59.

Anemophily (or wind pollination): a method of fertilization in which pollen is transported by wind. Synonym: anemogamy. II, 132; III, 59.

Aneuploid: a cell containing some extra chromosomes or fewer chromosomes than the normal formula. III, 17.

Aneurysm: the dilation of an arterial vessel into a sac shape, often affecting the large arteries (aorta and carotid). It is most often due to a weakening of the arterial wall owing to degeneration (atherosclerosis), infection (syphilis) or an accident. VII, 22, 130, 134, 137.

Angiography: radiography of the vessels after injection of a substance opaque to X-rays. This static method applied also to the observation of cardiac cavities (anglo-cardiography) has recently been perfected; eineangiography is now used, which is the dynamic study of vascular and cardiac cavities. VII, 26, 118, 122, 137.

Angiosperms: this is a sub-branch of the Phanerogams: the Angiosperms are divided into monocotyledons and dicotyledons; they are characterized by having their seeds enclosed in the fruit. III, 49, 50, 52, 64.

Anhydrobiosis: the maintenance of life without water. II, 59.

Animal intelligence: mental ability is attributed to some higher animals to explain complex behaviour that cannot be accounted for by instinct or apprenticeship. It implies the intervention of elementary reasoning and a rudimentary state of awareness. The animal which, without apprenticeship, seizes a stick to get hold of fruit placed outside its reach is not acting at random. It establishes beforehand a relation of cause and effect between its gesture and the result that follows. But contrary to what happens in man, who is capable of verbalizing his thought, it can only be shown in animals, even in primates (chimpanzees and gorillas) that there is unformulated thought. It has even been said until recently that there was only visual thought, or concrete thought, in opposition to the abstract thought of the human being. This opinion has had to be revised, however; in anthropoid apes the application of the stick idea to objects that could be considered as possible sticks, the use of certain objects as 'tools' for attaining the desired aim, must be considered as a rudimentary form of abstraction. In the same category must be placed the faculty of transposition possessed, for example, by parrots and jackdaws, and the use of abstract symbols such as money by certain chimpanzees. These animals learn very rapidly to put counters into automatic machines in order to get food or tit-bits, and they learn also to recognize the value of different coloured counters. It has been observed that some who have learnt this will try to exchange the counters they have been given with their fellows, so as to acquire a stock of the more valuable counters and will jealously guard this accumulated treasure. II, 91-96.

Anisogamy: this occurs when two reproductive cells (gametes) are very different (e.g. eggs and sperms). The opposite is isogamy. II, 49.

Anisometropy: disturbance of binocular vision, caused by differing refraction in the two eyes, which leads to a difference in size of the images seen by each eye. This difference is called anisocony. VI, 141.

Ankylosis: abnormal rigidity produced in a joint following either prolonged immobility, or fusion between the bones. VI, 142.

Annelids: a branch of invertebrates, animals bilaterally symmetrical, with a soft skin or covering and a body composed of a number of segments (metameres). II, 18.

Anopheles: a mosquito of the Culicidae family, vector of malaria. The anopheles is distinguished from other mosquitoes by the high position of its abdomen when it is resting. II, 150; VI, 42, 46, 47; VII, 74, 75; mi.

Anosmia: absence of the sense of smell. Specific anosmia is a disability that makes a person incapable of perceiving the smell of a particular substance while capable of perceiving others. V, 123.

Anoxia: reduction in the amount of oxygen in living tissues below the normal physiological level. Anoxia is the basic cause of asphyxia. VI, 83; VII, 51, 53, 65, 108, 125, 126.

Antagonism: a conflict between two or more individuals in order to occupy space. The phenomenon of antagonism between *Penicillium notatum* and other micro-organisms was the origin of the discovery of antibiotics by Fleming in 1949. Antagonism is also observed among bacteria. III, 72.

Anterior pituitary (or hypophysis): the anterior lobe of the pituitary (q.v.).

Antherozooid: the name given to spermatozoa of some plants, particularly the Thalophytes (Algae) and ferns. See Spermatozoon. III, 17, 57.

Anthers: small sacs containing pollen, situated at the end of stamens. The dehiscence of anthers liberates pollen. II, 127.

Anthocyanins: pigments that give flowers and leaves their colour. These pigments are glucosides. They are hydrolyzed by an enzyme into a glucose and a portion called aglycone. This portion, deprived of glucose, is known as anthocyanidine. Anthocyanidines are colour indicators; their colours change with the pH of the environment. This property explains the great variety of plant colours. III, 70.

Anthonome: a weevil that eats foodstuffs. The anthonome of apple-trees is common in Europe and North America. The cotton boll-weevil (*A. grandis*) was the cause of a serious cotton crisis in the southern United States at the beginning of this century. IV, 156, 157, 158.

Anthrax: an infectious septicaemic disease that affects cattle, notably sheep, horses and cows, but which may also be transmitted to man. It is caused by the anthrax bacillus (*Bacillus anthracis*) which shows itself by the appearance of pustules and ulcerations. Epidemics of anthrax are combated by means of vaccination and anthrax serum. VI, 63; VII, 79.

Anti-bacterial serum: serum from an animal that has received increased doses of emulsions of dead or living micro-organisms and has been subsequently vaccinated against these organisms. IV, 116, 117; VI, 30, 33, 47, 49-51, 116; VII, 28, 68, 79, 82, 89, 95-97, 104, 138.

Antibiotic: a substance produced by micro-organisms such as yeasts and bacteria which has the property of inhibiting the growth of other micro-organisms or of destroying them. Since the discovery of penicillin in 1929 by Sir Alexander Fleming, and especially since the work of H. Florey and E. Chain in 1938, the bactericidal properties of antibiotics have revolutionized the treatment of infectious diseases. It is now possible to combat certain diseases which before could only be dealt with by preventive vaccination. Antibiotics are produced by certain species of microscopic fungi, such as *Penicillium* and *Actinomyces*, and by some bacteria. Among thousands of antibiotic substances that have been tested over some twenty years, only a few dozen have been retained for use in medicine because of their low or non-toxicity to higher organisms. The four most important groups of antibiotics are penicillins, tetracylins, chloromycetins and streptomycins. Streptomycin is specifically used against tuberculosis, chloromycetin against typhoid fever; the penicillins and tetracylins (aureomycin and terramycin) have a wider range of action. Penicillins, of which the most used is still penicillin G, act mainly against streptococci, staphylococci, pneumococci, syphilis bacilli and gonorrhoea; they are practically without action on acid-resistant microbes, such as typhoid and typhus bacilli, etc. For some years it has been observed that penicillin G has become inactive on certain strains of staphylococci. This is not because resistance has been acquired by the microbes, but because there has been a selection: the strains sensitive to penicillin have been eliminated by penicillin, and only those are left which, having a special enzyme, penicillinase, defend themselves and destroy the penicillin molecules. In order to obviate this inconvenience, synthetic penicillins are now produced, the molecules of which cannot be destroyed by penicillinase. III, 72, 153; IV, 18, 42, 66, 146; VI, 10, 23, 26, 30, 31, 34, 49, 55, 65, 94, 116; VII, 9, 16, 38, 40, 41, 46, 63, 82, 83-88, 99, 149, 151.

Antibodies: a special blood protein (gamma-globulin) formed after introduction into the body of a substance foreign to the organism (an antigen). Each antibody is highly specific and possesses the property of combining with an antigen in order to neutralize the toxic effect. It is known that antibodies are manufactured by white cells, the lymphocytes, but the mechanism of their formation is still uncertain. The view currently held is that the antibody is produced inside the white cell by moulding of part of the antigen on to a pre-existing globulin of which the chemical structure is then slightly modified. One of the main difficulties of interpretation lies in the fact that the manufacture of an antibody lasts a long time after its antigen has disappeared from the organism: this, indeed, is the property which is used in vaccination. IV, 28, 112, 118, 127-131; VI, 23, 30, 33, 37, 43, 49, 50, 53, 56, 65; VII, 16, 53, 70, 71, 81, 82.

Antidromic: the contrary of orthodromic. V, 66.

Antifolic: a drug that is chemically close to folic acid. It behaves like an anti-vitamin and prevents certain intracellular chemical reactions. Hence, the antifolics combat cellular proliferation, which is one of the aims sought for in treatment of cancer. VII, 99.

Anti-haemophilia factor (A or B): a special protein of the blood (globulin) which activates coagulation. The absence of this substance is the cause of a serious hereditary disease, haemophilia. V, 35, 36; VII, 52.

Antigen: an antigen is any chemical substance of high molecular weight which, when introduced directly into the blood system of an organism that is foreign to it, is capable of causing the formation of a specific antagonist substance called an antibody. Antigens, which are extremely varied, are generally constituted by a protein nucleus to which various chemical groupings (polysaccharides and mucopolysaccharides) called haptens confer specificity. Many of the substances that make up pathogenic bacteria and viruses or are produced by pathogenic bacteria (exotoxins), are antigens; but certain particles such as dusts or pollens may also constitute antigens (called allergens) and cause disturbances such as asthma and hay fever.

The introduction of an antigen into an organism which already possesses the corresponding antibody produces an antigen-antibody reaction which may show itself in various ways: an agglutination reaction, opsonization, precipitation, or bacteriolysis. This property which leads to the specific neutralization of the antigen forms the basis of vaccination. I, 124, 125, 155, 156; IV, 28, 55, 58, 64, 106, 110, 128; V, 38, 40; VI, 37, 43, 49, 50, 51, 53, 55, 56, 65, 116, 130; VII, 17, 71, 82.

Antigen-antibody union: a measure of the attraction that an antigen and an antibody have for each other, eg, if a bacterial toxin is added to a serum containing the corresponding antitoxin, the toxin and antitoxin will combine with each other. This phenomenon is shown by flocculation; the two substances, once combined, become insoluble and fall to the bottom of the tube. IV, 129.

Antigen O: See Endotoxin. IV, 28.

Antihistamine: a drug capable of combating the effects of the liberation of histamine in the organism. An example is promethazine, sometimes known under the name of phenergan. VI, 51; VII, 68, 70-71, 150.

Antimetabolite: a chemical body which destroys living cells by inhibiting their metabolic processes. Antimetabolites often act in competition; that is to say, by replacing a metabolite with a chemical formula that is close to theirs. For some years, certain antimetabolites (6-mercaptopurine, for instance) have been used in cancer chemotherapy. Because of their action on metabolism and particularly on the synthesis of nucleic acid, anti-cancer antimetabolites are still of very limited use. IV, 66.

Antimitotic: see Cytostatic.

Antiseptic: a substance that destroys microbes or retards their multiplication, eg, alcohol, phenol, boric acid, etc. VI, 10.

Antiserum: a serum containing an antibody. The injection of a foreign serum into an animal causes the production of antibodies in its own cells. IV, 83, 84.

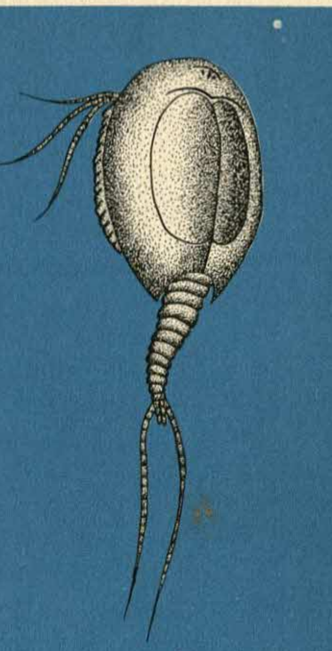
Antistreptolysins: Antibodies produced by the reaction in serum after the introduction of antigens linked to streptococcus. Haemolytic streptococcus A possesses several of these antigens (called lysins, eg hyalurodinase, streptokinase and streptolysin). When they diffuse in the organism these lysins cause the appearance of specific antibodies, the antistreptolysins. VI, 32.

Antitoxic serum: serum of an animal that has received at different times increasing quantities of microbial toxins and is then vaccinated against these toxins; eg, diphtheria serum, when injected in man, acts against diphtheria toxic infection. IV, 134.

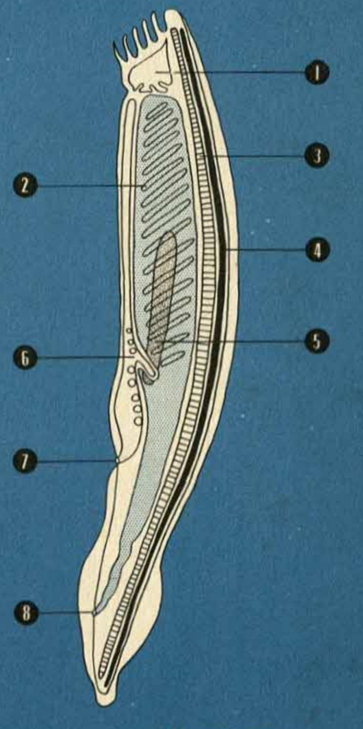
Antitoxin: a specific substance produced by the organism to combat the effects of a given toxin. VII, 81.

Ants: insects belonging to the order Hymenoptera. Ants include 7,500 species, of varying sizes and behaviour. Their habitat is very varied, consisting of suspended nests, made-up nests and ant-heaps. They are familiar with war, stock-rearing, slavery and politics (confederation of a number of ant-heaps observed by Forel) and offer the best-known example of the social division of work in the animal kingdom. II, 71; IV, 113, 114, 115, 118, 133, 134, 135, 136, 137.

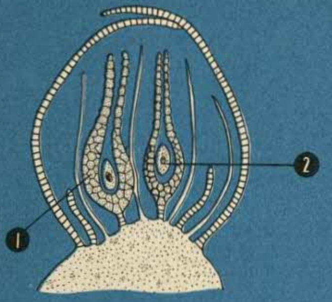
Anuria: absence of urine in the bladder, due to arrest of renal secretion. It is not urine retention, the patient does not



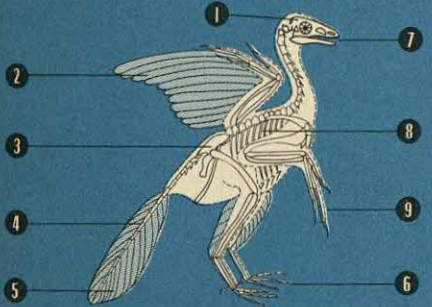
Apus



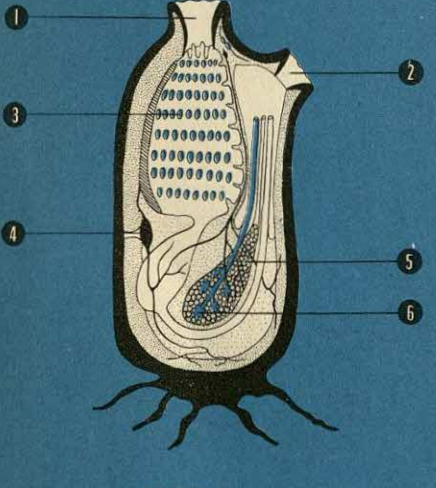
Amphioxus
1 Oral hood covering mouth. 2. Gill bars. 3. Notochord. 4. Nerve cord. 5. Mid-gut diverticulum. 6 Gonad. 7. Atriopore. 8. Anus.



Archegoniate
1. Archegonium. 2. Oosphere.



Archaeopteryx
1. Cranium. 2. Characteristic bird's wing. 3. Pelvis of a runner bird. 4. Row of twenty-two vertebrae. 5. Feathers. 6. Digits. 7. Conical teeth. 8. Slender ribs. 9. Well developed digits with claws.



Ascidia (section)
1. Oral siphon. 2. Atrial siphon. 3. Gills. 4. Heart. 5. Ovary. 6. Testis.

urinate and catheterization gives only perhaps a few drops of urine. VII, 51.

Aorta: the artery that leaves the left ventricle of the heart and is the beginning of all the arteries of the circulation except for the lungs. The arch of the aorta may carry congenital malformations, such as persistence of the arterial canal or coarctation of the aortic isthmus. VI, 84, 90. VII, 119-121, 127.

Aortic dextroposition: deviation of the origin of the aorta towards the right, causing it to lie astride the septum opposite an interventricular communication: in such cases the aorta receives the blood of the two ventricles. VII, 122.

Aortic infundibulum: a region in the shape of a funnel that separates the cavity of the left ventricle of the heart from the beginning of the aorta. VII, 119, 121.

Apex: the extremity of a stem or a root, ie the growing point. III, 63, 74, 75; mi.

Apico-basal gradient: a theory put forward by C. M. Child expressing the fact that certain physiological properties of living organisms are polarized, increasing or decreasing according to a regular gradient along a determined axis. Thus, in animals, there exists a gradient of sensitivity called apical-basal because it shows its maximum in the apex (head) and its minimum in the base (tail). I, 87, 88.

Apidae: insects of which the best known type is the bee. The Apidae are included in the Hymenoptera and are a very extensive family embracing thousands of species. II, 130, 131.

Aplasia: atrophy due to arrest of development of a tissue of an organ occurring after birth; gonodal aplasia is arrested development of the sexual glands. The atrophy expresses the diminution of volume of an organ in relation to variable anatomical lesions. VII, 31.

Aplasia, gonadal: an anomaly in the formation of the genital gland rudiments, showing itself by an absence or extreme reduction in the size of these glands. I, 146.

Apnoea: a stoppage, voluntary or otherwise, of lung ventilation. VII, 61.

Apoenzyme: a colloidal protein substance adjuvant to an enzyme that is not dialysable. The apoenzyme is united to a co-enzyme in a reversible reaction. V, 50, 51.

Apogamy: a form of reproduction; development of the embryo beginning with a cell of the embryo sac other than the ovule. III, 19.

Aposporia: development of a gametophyte from a sporophyte without chromatic reduction. Aposporia is observed in ferns and some angiosperms. III, 19.

Apprenticeship: a process by which an animal acquires certain behaviour patterns that are different from its innate instinctive activities, either under the influence of the group of the species with which it lives, or because of a human experimenter. A particular example of apprenticeship is training in horses. II, 139.

Appressorium: a swelling in plants produced by a parasitic organism in contact with a parasitized cell. III, 68.

Apraxia: (1) loss of comprehension of the use of objects, showing itself by more or less absurd actions; (2) the impossibility of making a movement conform to what is intended, although the victim has neither paresia nor ataxia. VII, 59.

Apus: a small crustacean the body of which is covered by a dorsal shell. Apus is closely related to the trilobites of the primary era. II, 25, 26; mi.

Arachnoid: a very delicate meningeal membrane to be found between the dura mater (q.v.) and the pia mater (q.v.). The space between the arachnoid and the pia mater is filled with cerebro-spinal fluid. VI, 60; VII, 135.

Araucaria excelsa: a large South American conifer with horizontal branches. III, 79.

Arborescent strata: superimposed layers of types of vegetation at different altitudes above forest soil. III, 123.

Archaeopteryx: a fossil animal of the Jurassic period that displays an intermediate form between reptiles and birds. It had teeth and has been placed in the Archaeornithes, characterized by a long tail. I, 18; II, 23, 33, mi.

Archegoniata: plants which possess archegonia. The archegonium is a multicellular organ, shaped like a bottle, which encloses a female cell in its lower swollen part (the haploid ovum) that is to be fertilized by a male nucleus. Archegonia are to be found in the Bryophytes (mosses) and the Pteridophytes (ferns). III, 79; mi.

Archenteron: the digestive cavity of the embryo formed during the course of embryogenesis during the gastrulation stage. The base of the archenteron is formed by the endoderm and its roof by the notochord and by the mesoderm. The archenteron communicates with the outside through the blastopore. I, 134; mi (Embryo).

Archipallium: the cerebral cortex of the most primitive vertebrates. In mammals and in man, it exists in very limited areas and is found in relation with the olfactory system (rhinencephalon). V, 86, 87.

Arterial canal: communication persisting after birth between the pulmonary artery or its left branch and the aorta, setting up a shunt which is most often left-right between the systemac and pulmonary circulations; cardiac surgery easily eliminates this malformation by ligature. VII, 118, 126.

Arterial hypertension: a syndrome caused by increase in pressure in the arteries of the systematic circulation, characterized by a heavy pulse, a maximum tension or pressure above 170, which may reach 250, and a minimum pressure above 100 mm Hg. VI, 11, 83, 87-91, 94; VII, 47, 56, 130.

Arterial pressure: the pressure of blood in the arteries. This pressure is not constant: it has a maximal systolic value corresponding to the contraction of the cardiac muscle and a minimal one corresponding to the relaxation of the cardiac muscle. These two figures are registered with special apparatus (Pachon's oscillometer). V, 91-95; VI, 87-91, 98, 102; VII, 14, 134, 135.

Arteriography: radiography of a section of an artery, after injection into the main arterial trunk of a substance that is opaque to X-rays. VII, 130, 137.

Arteriosclerosis: degeneration of the arterial vessels, shown by a thickening and hardening of the walls of the arteries. It must not be confused with atherosclerosis. VI, 11, 83.

Arterio-venous communication: abnormal communication between a vein and an artery. It is either traumatic because of an aneurism or a pulsating haematoma, or it is congenital. If untreated it may affect the heart. VII, 120, 134.

Arteritis: lesions of the wall of the arteries, of inflammatory or degenerative origin, leading to a thickening of the wall and sometimes to a dilation or obliteration of a vessel. VII, 105, 130.

Arthropod: articulated and segmented animals, such as shrimps. The articulations are required owing to the presence of chitin, a hard shell-like material on the surface of the skin. Their articulated appendages are adapted to various functions. The general cavity is reduced to a collection of gaps where the blood circulates. The nervous system is ganglionated. The development of these animals is interrupted by a series of moults and very often is accompanied by metamorphoses. II, 15, 18, 67.

Arthroses: a non-inflammatory degenerative chronic disorder of the joints, occurring after middle age and characterized by cartilaginous lesions. It shows itself in the form of pain, deformations, cracking, immobility without ankylosis, particularly at the knee, the ankle, the articulations of the spine, and the fingers. VII, 156.

Arytenoids: cartilage of the larynx, on which are found the insertions of the muscles of the vocal cords. V, 133.

Ascidia: these animals are Urochordates, forming part of the Protochordata. The notochord is situated in the caudal region; in the adult state the body is a kind of trap with two openings (a buccal inspiratory siphon and an expiratory cloacal siphon). The nervous system is represented by a single ganglion. Ascidia live on the sea floor. Some species are edible. I, 56; mi.

Ascobolus: a fungus of the Discomycetes order. Two related varieties of ascobulus have different methods of reproduction; *Ascobolus magnificus* is reproduced by the union of two gametangia; *Ascobolus citrinus* by the union of two of its own identical nuclei (parthenogenesis). III, 60.

Ascomycetas: a class of fungi characterized by the formation of an ascus. III, 48, 58.

Asexual reproduction: reproduction that is carried out not by the fusion of a male cell with a female cell (gámete) but by some other process: in bacteria, by the division of a cell into two identical cells. IV, 30.

Ascorbic acid: see Vitamin C.

Ascus: in plant anatomy, a small sac contraining characteristic spores of ascomycete fungi, such as the morels and truffles. III, 48, 49, 58.

Aseptic animal: an animal which appears to be without microbes (bacteria, viruses or parasites); a relative concept depending on the means of detection used. It is possible, for example, that certain viruses cannot be detected in the absence of a cytopathogenic action on the cells used in tissue culture. II, 144, 145; IV, 149-151, 154-158.

Aspergillus nidulans: a pathogenic fungus causing lesions of the skin, known as mycetoma. IV, 147.

Aspergillus niger: an ascomycete fungus of the aspergillate order. It has been used in Raulin's experiments in the nutrition of heterotrophic plants. III, 31, 34; mi.

Association of organs: a culture of cells derived from two or more organs in the same medium. These organs may come from the same individual or from two individuals of the same species, or from individuals of two different species. I, 82, 83, 84.

Association of tissues: a culture of two different tissues in the same medium, which forms a mixed tissue or a 'chimera'. These tissues may come from the same species or from two different species. I, 74, 76.

Asthenia: depression of the general condition, leading to multiple functional insufficiency. The term designates also a weakening of the functions of an organ or of a system, for instance, cardiovascular asthenia, neurasthenia, and myasthenia. V, 135-140.

Asthma: a state of hypersensitivity localized in the respiratory apparatus, leading to chronic inflammation of the bronchi. Asthma is linked, generally, to the inhalation of particles of dust, pollen or yeast, but it may also be due to allergenic substances present in the blood. Recent research has shown that an important part is played by psychological factors in the development of asthma. Present treatment of this disease combines the psychological approach with the neutralization of hypersensitivity by means of an appropriate medication. VI, 14, 52-57, 147; VII, 9, 66-68, 70.

Asthma, cardiac: dyspnoea of the same kind as typical asthma, but linked with cardiac insufficiency, or left ventricular insufficiency. VII, 153.

Asynchronous activity: electrical activity of the brain resulting from the functioning of nerve cells which is spread over a considerable length of time. It is the opposite of synchronous activity, ie, a large number of neurones becoming active at the same moment and, because of this, supplying electric signals of greater amplitude. V, 71.

Ataraxics: see Tranquillizers.

Ataxia: pathological lack of co-ordination of movement.

Atheroma: degenerative disorder of the cardiovascular system in higher vertebrates, showing as lesions of the internal lining of the arteries and developing into fatty and chalky deposits, the result of which is to reduce the flexibility and the diameter of these vessels. V, 137; VI, 85.

Atherosclerosis: a variety of arteriosclerosis; lesions characterized by an accumulation of cholesterol in the internal wall of the artery; this results in a diminution in the width of the vessel and hence of its usable diameter. V, 139; VI, 11, 83, 84, 109, 110; VII, 23, 62, 130.

ATP: abbreviation of **a**denosine-**t**ri**p**hosphate. A chemical compound that plays an important role in cell metabolism, particularly in the Krebs cycle. ATP has two energy-rich chemical bonds; muscle derives energy from the hydrolysis of ATP into ADP. I, 46, 47, 64, 155; III, 26, 27; V, 127, 128, 129, 146.

Atresia, tricuspid: a more or less complete occlusion, either congenital or acquired, of the tricuspid valve that separates the right auricle from the right ventrical. VII, 122.

Atropine: an alkaloid extracted from belladonna. Atropine is an antispasmodic medical preparation and is used for digestive spasms and bladder, urethral or bronchial spasms. It dries up skin secretions and also causes dilation of the iris by paralyzing the parasympathetic nerve. Atropine is used in very weak doses because it is toxic. VII, 150.

Atta: a species of South American ant (*Atta cephalotes*) that cultivates fungi underground, on which it feeds exclusively. These mushroom farms may extend for several square yards. II, 115.

Auriculo-ventricular dissociation: a cardiopathic anomaly caused by a lesion of the conducting bundle inside the heart, which conducts excitation from the auricles to the ventricles (bundle of His). The ventricles beat to a very slow autonomous rhythm, independent of that of the auricles, which remain normal; there is thus a great diminution in the frequency of heartbeat, the rhythm in certain cases may fall to forty or thirty contractions per minute and lead to death during the course of a syncope. VII, 122.

Auto-allergy: sensitization of an organism to its own chemical constituents. IV, 138.

Auto-antibody: antibodies which a person produces himself against his own organs or cells; for example, there is a haemolytic anaemia produced by antibodies linked to the production of anti-red cell antibodies produced by the subject himself. VII, 101.

Auto-defence: defence of the organism by means of certain internal mechanisms; eg, phagocytosis. IV, 112.

Auto-ecology: ecology of the isolated individual, as compared with synecology. III, 114, 117.

Autogamy: in plant physiology this is a method of fertilization where pollen and ovule belong to the same flower. Autogamy exists also in certain unicellular organisms, the paramecia. In place of sexual fertilization (conjunction), the nucleus of a single individual divides by meiosis, followed by fusion of the two halves; this is followed by self-fertilization. I, 104; II, 127, 130; III, 67; VI 130.

Autograft: transplantation of tissues in the same individual. I, 83.

Autolysis: destruction of cells that have died by the action of the enzymes that they contain. IV, 112, 113.

Autonomic system: the nervous system that regulates visceral functions; it is formed of ganglia and nerves and is linked to the cerebro-spinal axis that contains the reflex centres. The system includes the sympathetic system and the parasympathetic system that innervate the same organs and have antagonistic effects. V, 12, 13, 60, 61; VII, 56, 63, 129-130.

Autosome: an ordinary chromosome that is so called in opposition to sex chromosomes or heterochromosomes. I, 113, 114, 135, 143.

Autosterility: the contrary of autogamy. Autosterile plants have flowers that are hermaphrodite, but the pollen of one plant is incapable of fertilizing flowers of the same plant. II, 130, 131.

Autotrophic: capable of obtaining nourishment from exclusively mineral substances. I, 58; III, 11, 23, 24.

Auxins: a group of plant-hormones of varying kinds, having the same physiological action on growth of plants; auxins are especially active in the elongation of stems, in cell division, and in the production of fruit. I, 72; III, 36, 83, 86-88, 89.

Axolotl: the larva of *Amblystoma*. These larvae are able to reproduce themselves in their larval form (neoteny). The albino animals used for ornamental purposes were obtained from mutants from the Museum of Natural History in Paris. I, 92; II, 33.

Axon: prolongation of the nerve cell traversed by nerve impulses. The impulse displaces itself from the cell body towards the extremity of the extension. The ends of an axon enter into contact with dendrites or other nerve cells, or with muscle fibres (motor-end-plate). Axons formed in bundles make-up nerves. I, 88; II, 74; V, 75, 76, 131; mi.

Axoplasm: cytoplasm contained inside the membrane of the nerve fibre. V, 62, 63.

Axotaemia: the presence of the products of nitrogen excretion (urea) in the blood. Normally, the level of blood urea is between 0·25 and 0·45 g per litre. VII, 62.

Azotobacter: a common bacterium of cultivated fields. It lives on the roots of leguminous plants and fixes atmospheric nitrogen. IV, 62, 72.

B

Bacilli: bacteria shaped like rods; many bacilli are pathogenic. IV, 24; VI, 18, 19, 23, 26.

Bactericidin (or bacteriolysin): a substance contained in the sera of mammals that is capable of inhibiting the growth of bacteria, especially Gram-positive ones, or of destroying them. Bactericidins may be produced by leucocytes (leukines) or by blood platelets (plakines). IV, 118, 120, 121.

Bacteriolysis: destruction of pathogenic bacteria by the successive action of two substances contained in serum, a thermostable sensitizer, which is the specific antibody, and the thermolabile complement which is non-specific. IV, 129.

Bacteriophage: a specific virus which is a sub-microscopic agent infecting bacteria. These are obligatory parasites, as are the other viruses, but differ from them in a certain number of characters and morphological particulars. They are formed by a 'head' which is hexagonal or elliptic and from 50 to 100 millimicrons in diameter, and a 'tail' which is contractile and approximately 100 millimicrons long. They are essentially constituted by a thin layer of DNA, concentrated in the head and protected by a layer of specific protein in the tail around a central axis. The bacteriophage fixes itself on the bacterium by means of its tail, and after having digested the bacterial wall by means of a special enzyme, it injects its own DNA. This, by substituting itself for the DNA of the bacterium, modifies the metabolism of its host; it multiplies very rapidly and destroys the bacterium by lysis. In certain cases, however, the bacterium does not die; a kind of symbiosis is established between the bacteriophage and its host, which is known as lysogeny. The virus, in the form of an incomplete virus, or prophage, integrated into the chromosome of the bacterium, is then transmitted through a number of generations; after this it suddenly becomes virulent again and carries away with it a bacterial gene which is transferred to a new host (transduction). During the last few years bacteriophages have been chosen for use in the most advanced genetic studies, and it is on the phage T^4 of the intestinal bacterium *Escherichia coli* that studies are being carried out in order to decipher the genetic code of the regular succession of hereditary character. I, 119, 120, 123, 124, 126; III, 71; IV, 10, 19, 20, 38, 44, 58, 91, 92, 106, 107, 108, 110; mi.

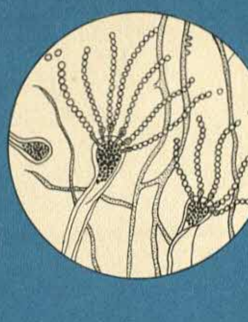
Bacterium: a microscopic unicellular living organism with either a long (bacillus) or a round (coccus) shape; its size varies between 0·5 and 20 microns. Bacteria have a cytoplasm provided with mitochondria and other functional bodies; the nucleus is atypical, containing a single chromosome and is deprived of nuclear membrane. Although bacteriology is now one of the most important branches of medical research and of experimental biology, the place of bacteria in classification is still a subject of discussion: owing to the presence of pigments or of a rigid cell envelope they are often classified with plants, but their particular characters, such as atypical nucleus, sporulation, and L-forms, suggest that bacteria form a separate group. The majority of bacteria live as saprophytes in the soil or in water. They are autotrophic and several are capable of using elements other than oxygen for respiration. They play a very important role in the big plant cycles, the nitrogen cycle, the carbon cycle, and the sulphur cycle. Certain of them, cultivated by man, have been used on an industrial scale in fermentation in the production of vinegar and alcohol and in the manufacture of certain chemical products, such as antibiotics and Vitamins B_{12} and C. A great number of bacteria, on the other hand, are parasites and pathogenic, such as staphylococcus and colibacillus. These are responsible for many infectious diseases, both in animals and in man. II, 14, 15, 16, 56, 57, 61, 64, 68, 69, 70; III, 18; VI, 9, 14, 15, 19, 22, 30, 38, 54, 56, 65; VII, 38, 40, 80, 81, 85-88, 90, 95.

Ballistocardiograph: the recording of the impulse communicated to the human body by the rebound wave caused by the heart-beat. The apparatus consists of a mobile table, set horizontally, on which the patient lies. The vibrations transmitted are recorded through a metallic bar placed across the patient's tibia. VII, 23.

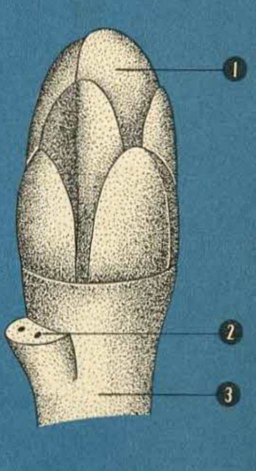
Barbiturates: hypnotic preparations derived from malonylurea, which induce a calm and restful sleep analogous to normal sleep. VII, 54.

Baro-receptor (or presso-receptor): a nerve receptor sensitive to variations of arterial pressure. The best-known baro-receptors are situated on the wall of the aortic arch and at the level of the carotid sinus. V, 94-95; VI, 87-88.

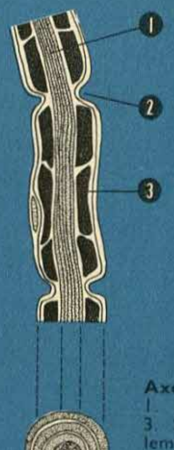
Basal metabolism: the metabolism of a person under basal conditions, that is to say resting, without food and at a temperature that constitutes thermal neutrality (no



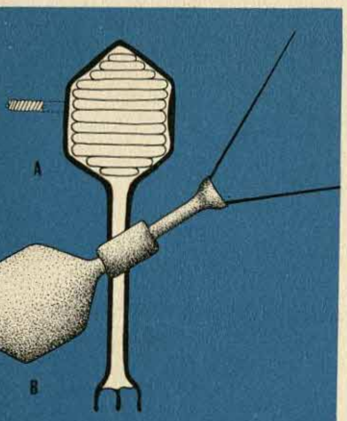
Aspergillus



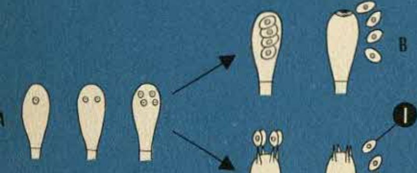
Axillary bud
1. Scale leaf. 2. Leaf scar. 3. Stem.



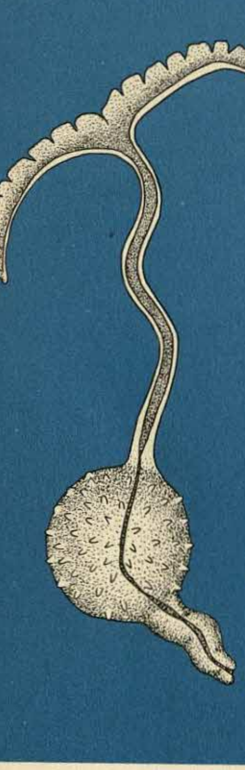
Axon
1. Axon. 2. Ranvier's node. 3. Sheath of Schwann (neurilemma).



Bacteriophage (T_2)
A. Before attachment to a bacterium: opened to show the position of the nucleic acid. B. After excitation by bacterial substances.



Basidiomycete
A. Meiosis. B. Ascus. C. Basidium. I. Spores.



Bonellia

effort to achieve thermo-regulation). Basal metabolism is approximately 1,500 calories in 24 hours for an adult man weighing 70 kg. Certain variations of basal metabolism may be produced physiologically (through pregnancy and suckling), or pathologically (hyper- or hypothyroid and diabetes). V, 52, 72, 135; VII, 14.

Basal pole: in vascular plants, part of the stem on which the roots form. III, 77.

Basedow's disease: a disorder characterized anatomically by diffuse hyperplasia of the thyroid epithelium, leading to an abnormal and excessive secretion of hormone. Clinically it is characterized by an increase in volume of the thyroid gland, tachycardia, exophthalmia, a kind of trembling, loss of weight, and a marked elevation of basal metabolism together with an accelerated fixation of injected radioactive iodine in the thyroid gland. V, 52.

Basidiomycetes: a class of higher fungi, characterized by the formation of basidia, or spore-carrying sacs. In the basidium, the spores are outside the sac and carried on pedicels. III, 48, 58; mi.

Basilar membrane: in the inner ear, a flexible and elastic membrane forming the base of the spiral of the cochlea, supporting the structures that make up the organ of Corti. V, 114, 115, 118, 119.

Basophilia: the cell protoplasm's property of fixing certain basic dyes or stains. The cells that possess this property are said to be basophil (eg, basophil polymorphonuclear cells, basophil cells of the anterior pituitary, etc.). I, 109; II, 62; V, 28; VII, 31, 35.

Batrachia: see Amphibia.

BCG (abbreviation of Bacillus Calmette-Guérin): the tuberculous bacillus of bovine origin, rendered harmless by successive passages on media with derivatives of bile. BCG is used in subjects allergic to the tubercle bacillus, that is to say, whose organism has never been in contact with the bacillus. BCG makes them allergic and increases their immunological defences. IV, 4, 45; VI, 26, 27, 28; VII, 80.

Benthic: describes animals that inhabit the bottom of the sea (or fresh water) in opposition to surface plankton. II, 55, 56.

Benzyl-penicillin or Penicillin G: a penicillin manufactured industrially from a selected strain of *Penicillium chrysogenum* (a mould) that is stable in the presence of acid; it can only be used parenterally. VII, 84-85.

Beri-beri: an illness caused by an acute deficiency of Vitamin B_1 (thiamine). It is still frequent in South-East Asia and in Malaysia and is characterized by extreme fatigue and polyneuritis; other symptoms are oedema and cardiovascular disturbances. VI, 109, 110.

Beta rhythm: electroencephalograph rhythms registered in the anterior part of the brain. These are more rapid than alpha rhythms (15 to 30 cycles per second), and of weaker amplitude. They appear when the subject is attentive and has his eyes open. V, 71, 72.

Bile: a slightly alkaline liquid secreted continuously by the liver, which produces about two pints every twenty-four hours. This is placed in reserve and concentrates in the gall bladder, from which it flows into the duodenum at the moment of digestion. Bile helps digestion and enables the intestine to absorb fats; it neutralizes the acidity of the gastric juices and helps to eliminate certain foreign colouring substances. VII, 28.

Bilharziasis: a parasitic disease, caused by parasitic worms in the circulatory system which are called schistosomes. These worms go through a cycle that requires them to pass through a freshwater snail which harbours their eggs. Depending on species and on the mode of contamination, they fix themselves in different organs. There is bladder bilharziasis with haematuria (Egypt), and a hepatic bilharziasis with a cirrhotic syndrome (Japan). VI, 40; VII, 78.

Biliary pigments: pigments formed in the liver from the haemoglobin of old red cells that are destroyed there. Biliary pigments in urine, the blood, and the mucosa (jaundice) are a common symptom of many diseases. VI, 104; VII, 28.

Bilirubin: a biliary pigment produced by the degradation of haemoglobin which gives bile its yellow-brownish colour when it is formed by the liver. VII, 28.

Binocular vision: the result of the coordination of the two eyes in their simultaneous use; the superposition of two images gives an impression of stereoscopic relief. If this relief is still perceptible, although to a lesser degree in uni-ocular vision, it is by the 'relief habit' of binocular vision. IV, 141.

Biochemistry: the chemistry of living beings. Biochemistry has two different aspects: the first, a theoretical aspect, defines the composition of the substances that constitute living matter, such as cells, tissues and organic fluids. The three main categories of organic substances are: proteins, lipids and glucosides, and there are also some more complex derivatives such as lipoproteins, mucoproteins and nucleic acids. The nature of these is now well known, a certain number of physical and chemical methods having been developed, particularly chemical analysis and differential ultra-centrifugation which separate the cell constituents, etc. As well as with the chemical analysis of constituent molecules, biochemistry is concerned with carrying out a total or partial synthesis of certain constituents; X-ray crystallography is able to show the arrangement of organic molecules in space; this is called stereochemistry. By this means it has been possible to determine the helical structure of DNA and the structure of the 'nucleus' of haemoglobin. The second aspect of biochemistry, the more practical one, is the study of chemical reactions produced in an organism, whether they be unicellular or multicellular, starting from the supply of external materials, such as foods and oxygen, to the elimination of waste matter, such as carbon dioxide. In other words, biochemistry is the study of metabolism, whether it be constructive metabolism (anabolism), such as photosynthesis or the assimilation by cells of nutritive elements in the blood, or destructive metabolism (catabolism) such as cellular respiration or lactic fermentation. Also to the field of biochemistry belong all the intermediary reactions of metabolism ('metabolic crossroads', the Krebs cycle) and all the reactions by which the metabolism of lipids or glucosides join those of protein (molecular rearrangements, transfer of an amine radical, etc.). Metabolic reactions cannot normally proceed with the action of enzymes, so the study of catalysts and some of their constituents, such as cytochromes and vitamins, constitutes an essential branch of biochemistry without which it is difficult to understand the mechanism of vital processes. I, 39, 40-43.

Biocœnosis: a community consisting of an assortment of animal species that inhabit any given environment and that are relatively constant within the limits of a restricted area. This restricted environment, called biotope, includes the sum of the contained plant and animal species. II, 55, 56, 154; III, 116, 117; IV, 54, 55, 154.

Biological clock: a physiological mechanism in plants and animals which enables them, or so it appears, to have a knowledge of time and to take account of it, even if the normal indicators of day and night luminosity are lacking. Experiments carried out on plants and animals show that this mechanism is of internal origin; its process is not yet entirely clear, at least in plants (see Photoperiodicity); but the work of J. Harker on insects has provided some new information. The awareness of time might be due in them to the secretion of a hormone released periodically under the influence of a still unknown factor, in special neurosecretery cells of the brain of the insect. III, 19, 91, 92.

Biological cycle: a series of biological phenomena succeeding each other in a determined order, in such a way that after a complete cycle a return is made to the first stage. Biological cycles are a common phenomenon and all living beings, animals or plants, go through numerous cyclic variations. Such cycles may be aperiodic and may reproduce themselves at varying intervals. But in most cases variations are periodic and the interval of time separating two identical phases is usually constant. Among the aperiodical cycles are those of parasites and bacteria; for example, in parasites that require a number of successive hosts, after the end of a phase the following stage of development does not occur unless the parasite meets the following host. The intermediate phase, in the form of dormant cysts or disseminated eggs or even a vegetative form, may thus vary between a few hours and some years; in such a case the development of the cycle is a matter of chance. In bacteria, the term life cycle is applied to the alternation of normal form and dwarf form (the L-form) passing through a series of intermediary forms. Here again, as with the transformation to L-form and the return to normal form, there are external non-periodic factors (culture conditions, the addition of certain chemical substances) hence the cycles does not evolve in a regular fashion. It is quite another matter with periodic cycles, which depend on the regular alternation of certain physical or chemical conditions of the environment. Such are the growth cycles of plants, flowering cycles, and fructification cycles, which depend on the regular return of a certain amount of light and heat. Again, the sexual annual cycles of animals go through a constant rhythm of seasons, as do the oestrous cycle of female mammals, the seasonal migrations of fish and birds and the hibernation of certain mammals. I, 105; II, 53, 54; III, 56-58; IV, 106.

Biological equilibrium: a state in which the 'level of population' of a number of species fluctuates only slightly, the level being a result of the interdependence of these species and of the reciprocal actions that they exert on one another. II, 154, 155.

Biopsy: the surgical removal from a live patient of a fragment of tissue or organ in order to analyze or observe it. Biopsy is practiced, for instance, in the diagnosis of cancer, V, 57; VII, 28-30, 36, 54.

Biosphere: a region in which physical and chemical conditions make organic life possible. IV, 73.

Biotope: a definite biological environment, such as a pond or a grotto. II, 136, 154.

Birds: biped aerial vertebrates whose anterior limbs, transformed into wings, are used for flying. Their skin is covered with feathers, their respiratory apparatus has two lungs and air-sacs, their kidneys are metanephric, and they are oviparous and homeothermic.

Blastocoel: the cavity of the embryo at the blastula stage. I, 133, 135.

Blastoderm: on the embryo, a layer of cells that limit the blastocoel or cavity of the blastula. I, 135.

Blastogenesis: the capacity of cells of part of an animal to form a bud, thus participating in the production of a new organism and bringing about asexual reproduction. I, 102.

Blastomere: a cell derived from segmentation of the fertilized egg, during the first stages of embryonic development. I, 134, 135.

Blastopore: in the embryo, the depression that occurs on the surface of the blastula and leads to the formation of the archenteron, or primitive intestine. Beginning with this stage, the blastula transforms itself into the gastrula. I, 134.

Blastula: a stage of embryogenesis during which the egg, which has divided into some hundreds of cells (blastomeres), forms a small hollow sphere, the cavity of which is called the blastocoel. It consists of only one layer. I, 133, 136; III, 13; mi (Embryo).

Blenny: a type of fish common on the Atlantic coasts, about 8 inches long. Blennies live in groups in pools bordering the sea. II, 36.

Blennorrhagia: see Gonorrhoea.

Blood bank: a specialized medical centre which collects and stores human blood for transfusion and for operations with the artificial heart-lung. The blood thus collected is separated into fractions, each of which has a particular use: serum, red cells, white cells, platelets, etc. V, 32, 33.

Blood groups: the name given to different types of blood in the human species. The identification of the group to which any person belongs is essential because it is dangerous to mix the blood of two human beings taken at random without first ensuring, before carrying out a transfusion, that the blood groups of the donor and of the recipient are not incompatible. There are several different blood group systems, of which the most important is the ABO system. There is in the serum of certain persons a special substance, agglutinin, which has the property of causing agglutination in red cells in other persons; this phenomenon is caused by the presence, in red cells of the donor, of an agglutinogen, acting as an antigen, which combines specifically with the agglutinin of the recipient. There are two agglutinogens, A and B, and two agglutinins, anti-A and anti-B, and from the existence of four blood groups, called A, B, AB and O, it follows that blood contains agglutinogen A or agglutinogen B, or the two together, or neither of the two. It goes without saying that the agglutinin corresponding to the agglutinogen cannot exist in the same blood, otherwise an agglutination of the cells would be produced automatically and this would be incompatible with life. Group A possesses, therefore, agglutinin anti-B; group B, agglutinin anti-A; group AB, no agglutinin; and group O, both agglutinins. In practice, only group O may be considered as universally usable; transfusions practised with blood of group A, B or AB must be given with certain precautions. The discovery of sub-groups A, A_2, A_1, B_2 and A_2, B_1, as well as groups M, N, P, has complicated the over simplified scheme of four fundamental groups. The rhesus factor has enabled us to understand certain cases of blood incompatibility (for example, the haemolytic disease of the new-born). Blood groups are transmitted according to the laws of Mendelian heredity and their systematic study allows us to estimate the affinities or differences between several groups of human beings. V, 38-40; VII, 53, H.

Blood islands: in the embryo of vertebrates, a mass of cells that constitutes the first rudiments of the circulatory system. These cell masses, derived from the internal layer of the mesoderm, the splanchnopleura, are at first full, but become hollow with cavities formed in such a way that the cells of the periphery give birth to the walls of blood vessels and the central cells to certain blood cells. I, 154.

Blood pressure: see Arterial pressure.

Blood transfusion: a technique that is one of the main weapons in resuscitation. Total blood transfusion permits the transfer of those elements that are required for the transport of oxygen, the defence against infection, and the formation of a platelet plug (a white thrombus). It allows the circulating blood to be re-established and corrects conditions of shock and vascular collapse. It also supplies those coagulation factors that are required for haemostasis. Modern transfusion methods now only use indirect transfusion of blood from bottles in ACD solution (acid, citrate and dextrose). The blood may be stored for two to three weeks in a refrigerator at +4°C. V, 29, 32, 33; VI, 82; VII, 50, 53, 63 (see Blood groups).

Blue disease: this designates all pathological conditions produced by congenital malformations of the heart and the large vessels, with a resulting blue coloration of the skin, which indicates a right-left shunt. This disorder is nearly always congenital. VII, 118, 122, 125, 127, 128.

Bluff, protective: in animal psychology, the behaviour of certain animals designed to frighten predators of which they are the victims. II, 125, 126.

Body temperature: the internal temperature of the body of an animal or man. IV, 126; V, 154.

Boil: an inflammatory swelling of subcutaneous tissue caused by a streptococcus. VI, 15.

Bone marrow: a yellowish tissue that occupies a bone cavity. It is composed of lymphocytes (with homogeneous protoplasm), and basophilic, neutrophilic, acidophilic leucocytes, red cells, vessels and capillaries. The marrow produces blood. V, 30; VII, 31, 98, 99, 101.

Bone tissue: a variety of connective tissue in which the ground substance or matrix, impregnated with calcium salts, has become rigid. Bone cells communicate with each other by very fine canaliculi. I, 67.

Bonellia: an invertebrate animal of the Echiuroid order which is found on the coasts of the Mediterranean. *Bonellia* shows a strong sexual differentiation. The male, which is very small, lodges in the oesophagus of the female, from which it migrates towards the genital organ at the moment of reproduction. I, 114; II, 49; mi.

Bordet-Gengou bacillus: (a synonym for *Haemophilus pertussis*): The bacillus responsible for whooping cough, which resembles the Pfeiffer bacillus, but is a little longer; it is often grouped in small bundles. It is Gram-negative, and sometimes more coloured at the poles; it exists in transparent colonies that are difficult to see and is cultivated in a potato medium with glycerine and blood. It is found in small drops emitted during coughing at the beginning of whooping cough. VII, 87.

Bordet-Wassermann: see Wassermann.

Bothriocephalus: a parasitic worm of the small intestine of man, of the Cestode class. The definitive host for *Bothriocephalus* is man and the intermediate hosts are a small crustacean (cyclops), and a fish. *Bothriocephalus* causes an important type of anaemia in man. II, 107, 108; mn.

Botulin toxin: a toxin secreted by *Bacillus botulinus*. It is usually found in cooked meat bought from shops, or in badly prepared meat pies, etc. The ingestion of this toxin produces a form of poisoning called botulism. IV, 81, 83, 84.

Botulism: see Botulin toxin.

Bowen's disease: a variety of dyskeratosis (disturbance of keratinization), beginning with limited lenticular plates or plaques in any part of the skin or mucosa and developing into a cancer. Bowen's disease of the mucosa is a variety observed in the vulvo-vaginal mucosa, and also lead to cancer. VII, 30.

Bowman's capsule: in the kidney of vertebrates, the membrane that covers the Malpighian corpuscle. VI, 93.

Brain: the higher nerve centres, consisting, in vertibrates, of cerebrium cerebillum, diencephalon, etc., within the skull. V, 69, 71.

Bright's disease: see Nephritis.

Bromo-sulphone-phthalein: a test designed to study the proper functioning of the liver by examining its chromagogue function. BSP injected into the veins (2 mg per kg of weight) is excreted by the bile and should disappear completely from circulation (normally at the end of thirty minutes). The abnormal persistence of BSP in the blood is a sign of hepatic cell lesion. VII, 20.

Bronchi: the two bifurcating channels of the trachea through which air is introduced into the lungs. VII, 11.

Bronchiole: a bronchus of very small diameter, of which the extremity opens into a lung alveolus. V, 13; VI, 58, 59, 62.

Bronchitis: a disease characterized by inflammation of the mucosa of the bronchi. VI, 53, 54.

Broncho-pneumonia: a disease characterized by inflammation of the parenchyma in the lungs or in the bronchi, most often caused by pneumococcus (*Diplococcus pneumoniae*). VI, 19, 22.

Bronchospirometry: simultaneous recording of the ventilation of each lung, obtained by the introduction of a special sound with two channels up to the level of the tracheal bifurcation which collects the air in the right and left lung and leads it to two separate spirographs. Normally, the right lung accounts for 55 per cent and the left lung 45 per cent of the lung ventilation. VII, 24.

Brucellosis or Malta fever: an infectious disease caused by a Gram-negative bacterium, *Brucella melitensis*, characterized by intermittent fever. VI, 51.

Bryophytes: a group of the plant kingdom including mosses and liverworts. Bryophytes show the phenomenon of alternation of generation. The developed plant constitutes the gametophytic generation on which there develops parasitically the sporophytic generation. III, 50, 57, 58.

Bubo: inflammation of a lymph node, particularly an axillary or an inguinal lymph gland. VI, 19

Bud, axillary: a bud which arises on the main stem and gives rise to branches. The axillary bud is so called because it develops as an 'axis' of the leaf, that is to say, at the point of junction of the leaf and the stem. III, 13.

Budding, vegetative: the formation in plants of an entire individual starting from a vegetative part of another individual. Natural budding is observed in the majority of aquatic plants (algae, etc.) and among the mosses. III, 16, 17, 67.

Buds, prostatic: in the mammalian embryo, masses of cells that arise on the wall of the urethra (below the neck of the bladder) and the mass of which is the rudiment of the prostate. I, 145, 150.

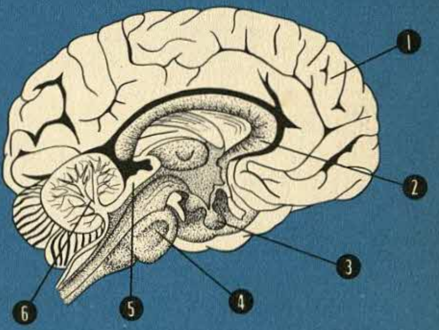
Buffer: a chemical substance added to a medium to prevent too large a fluctuation of pH; in other words, in order to prevent this medium from becoming too acid or too alkaline. IV, 59.

Buffer system: the mixture of a weak acid and its salt with a strong base or a weak base and its salt with a strong acid, which reduces variations of acidity or alkalinity of a solution. The pH of the blood remains constant and normally varies between 7·3 and 7·45 and is therefore slightly alkaline. This constancy of the internal environment is strictly maintained against the large variations of acidity or alkalinity which nourishment and metabolism tend to produce in the organism. It therefore implies the existence of automatic and immediate regulatory mechanisms in the plasma, which are called buffer systems. If large quantities of carbonic acid and bicarbonates are present in the blood, the carbonic acid/bicarbonate ratio is the most important factor in the regulation of blood pH. If a strong acid penetrates into the blood, the bicarbonates are decomposed, giving free carbonic acid. But since this free acid is very little dissociated, the pH will vary only slightly. It is for this reason that blood bicarbonates have been called the 'alkaline reserve' of the blood. VII, 51.

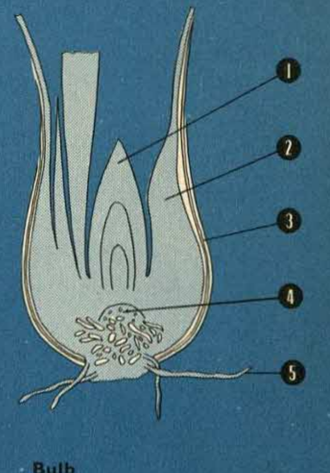
Bulb: a subterranean bud with fleshy leaves, such as onion, hyacinth, etc. Bulbs enable living plants to pass the winter sheltered from the cold. In spring, plants use the reserve contained in the bulb and it is from this that new leaves and adventitious roots develop. III, 100, 103; mi.

Buphthalmia: a considerable increase in the volume of the eyeball, produced in infants with congenital glaucoma. VI, 142.

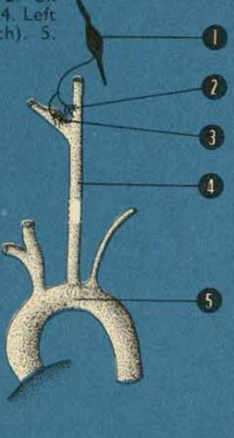
Bothriocephalus



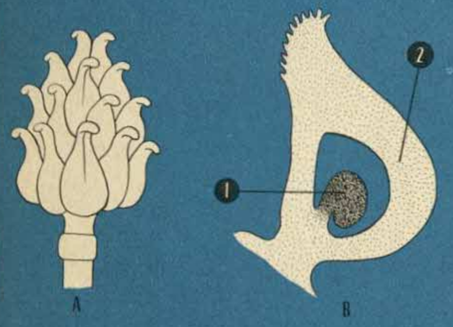
Brain (transverse section)
1. Cerebral hemisphere. 2. Corpus callosum. 3. Pituitary. 4. Cerebral peduncle. 5. Quadrigeminal bodies. 6. Cerebellum.



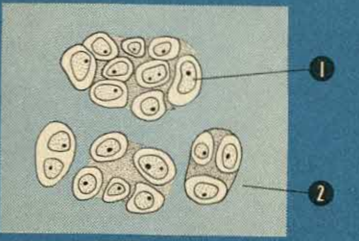
Bulb
1. Axillary bud. 2. Coat (fleshy leaves). 3. Sheath. 4. Flat stem. 5. Adventitious root.



Carotid sinus
1. Andersch's ganglion. 2. Ex Carotid. 3. Carotid sinus. 4. Left common carotid (L. Arch). 5. Aortic arch.



Carpel
A. Pistil with carpels. B. Section of a carpel.
1. Ovule. 2. Ovary.



Cartilage
1. Cell (chondrocyte). 2. Ground substance (matrix).

C

Caatinga: a type of thorn bush found in Brazil. III, 124.

Calamites sukhowi: fossil plants of the Carboniferous flora (end of Primary era). The calamites resemble the horsetails (Equisetum) of the present day. III, 53.

Calcium: a mineral element that forms part of the composition of living matter, particularly bone. The human body contains 2 per cent of calcium, mainly in two forms: calcium carbonate ($CaCO_3$) in the bones and teeth, and ionized calcium in the blood serum (57 mg per litre). Ionized calcium fulfils a number of functions: it is factor IV of coagulation and it is essential in bone formation. The metabolism of calcium is under the control of the parathyroid glands, of the oestrogen hormones, and of Vitamin D, which allows its fixation in bone. II, 58.

Calculi: stony aggregates formed by organic or mineral substances which sometimes occur in cavities (bladder, gall bladder, kidneys or the kidney pelvis) or in the excretory canals of these glands (the bile ducts and urethra). VII, 104.

Calculi, bladder: urinary calculi situated in the bladder, either formed in it or in the ureters and not eliminated; they often increase in size and become progressively loaded with mineral salts. VII, 110.

Callus: a clump of cells that forms on wound surfaces of animal or plant tissue. In vertebrates the formation of a bone callus is the first stage in the consolidation of a fracture. III, 36.

Cambium: a growing layer to be found between wood and phloem. It is composed of cells that divide actively and are responsible for the increase in growth and thickness of the stem. III, 36, 79, 80, 149.

Camouflage: an adaptation shown in certain animals by imitating their surroundings. The best-known examples of camouflage are the chameleon, the ray, and stick insects. A Mediterranean crab camouflages itself by sticking pieces of algae on top of its shell. II, 119-124.

Cancer: a physiological disorder caused by an anarchical proliferation of certain cells and characterized by the infiltration of abnormal cells into all parts of the organism (metastasis). It may be observed in all living beings and occurs in plants (the crown gall of the oak, for example), as well as in animals and man. Furthermore, it seems that no kind of living tissue, even nerve tissue, is proof against cancerous proliferation. The real causes of cancer are still unknown. Several theories have been put forward, but these may all be summed up under two main headings: according to the first, cancer is a form of infectious disease in which the infectious agent—a virus—invades the organism and causes a cell disturbance that results in a disordered multiplication of cells; according to the other theory, there is a genetic predisposition to cancer which, under the influence of a chemical agent (tar) or physical agent (ultra-violet or X-rays), or by a hormonal disorder, is transformed into the true disease. The experimental study of cancer on animals has resulted in great progress in our knowledge of how the disease appears and the way in which cancers are transmitted from one organism to another. Cell and tissue cultures of cancers have also led to an appreciable amount of knowledge about physiological modifications (pH, metabolism, etc.) which occur within the cancer cell. According to the most recent researches, the virus theory appears to be in the lead. About fifteen cancers affecting a number of different animal species can without doubt be attributed to the action of a virus; they include chicken sarcoma, chicken leukaemia, Shope papilloma, mammary cancer of mice, polyoma of mice, etc. It has been possible to obtain a certain condition of immunity against cancer and this has also lent support to this theory. But the possibility of genetic modifications (mutations) cannot be entirely excluded. Anti-cancer treatment is of three kinds: surgical, radiotherapy, and chemical. Surgery and radiotherapy are used in localized cancerous tumours. Chemotherapeutic treatment is used particularly for generalized cancers of leukaemia; it is based on the use of antimetabolites which block the metabolism of cancerous cells or of substances that prevent these cells from dividing. IV, 22, 66, 98, 100-105; VI, 62, 110, 112, 115, 121-130, 135; VII, 11, 14, 17, 22, 23, 29, 30, 34, 35, 89-91, 94-98, 104, 105, 110, 141, 151. H.

Cancer *in situ:* the pre-invasive phase of cancer, the diagnosis of which depends on cytological criteria of malignancy, no structural disturbance having, by definition, yet intervened. VII, 30.

Candida albicans: a microscopic fungus related to the yeasts which is parasitic in the human intestine, where it becomes pathogenic in the absence of the normal intestinal flora. VI, 55, 56, 64.

Capsule: in bacteriology, a gelatinous covering, composed of polysaccharides, surrounding certain bacteria. The capsule may be either a thin membrane or a voluminous mass. In botany, it is a fruit with a dry and dehiscent envelope (eg, poppy, shepherd's purse and pimpernel). IV, 25.

Carbomycin: an antibiotic produced by a strain of *Streptomyces halstedii*. VII, 87.

Carbon cycle: the various stages in the transformations undergone by carbon in nature. The cycle includes two fundamental stages:

1. Photosynthesis: transformation by green plants of atmospheric carbon dioxide into organic plant substances. These organic substances constitute feeding stuffs for animals.
2. Respiration: fermentation and combustion give back carbon dioxide to the atmosphere.

The first stage is carried out by means of the absorption of solar energy, the second is accompanied by the production of energy. I, 17; III, 19, 22, 23; IV, 74.

Carcinogen: any physical or chemical agent that may lead to the development of a cancer. VI, 110, 121, 127-129.

Carcinogenesis: the totality of factors and elements that determine the origin and development of cancerous tumours. IV, 32, 33; VII, 89, 91.

Carcinoma: a malignant epithelial tumour of which the fibrous stroma is crossed by alveoli forming a hollow system containing free cells in a more or less abundant fluid. VII, 94, 95-97.

Cardiac arrest, induced: a method for arresting heart-beat so as to permit surgical operation on the heart. Different methods are used, such as injections of potassium citrate in the coronary arteries, controlled anoxia, or extra-corporeal transfusion, together with refrigeration. VII, 128.

Cardiac catheter: an instrument for exploring the heart: the catheter, hitherto used only for exploring the bladder, is now used for exploration of the cardiac cavities. It is a thin, very long plastic tube, introduced through a vein in the arm in the direction of the heart, which allows direct measurement of pressure to be made in the different heart cavities. VII, 118, 121.

Cardiac centres: nerve centres situated in the medulla oblongata controlling the rhythm of the heart. V, 92.

Cardiac output: the volume of the systolic output in relation to the number of heart-beats per minute. V, 91; VII, 25, 29.

Cardiopathy, congenital: a generic name for congenital disorders of the heart. VII, 118, 119.

Cardiovascular malformations: see Cardiopathy.

Caries: a disorder characterized by the softening and progressive destruction of tissues of the tooth. It always occurs from the outside towards the inside. VI, 118.

Carotinoids: a group of substances derived from an orange pigment that is abundant in carrots. Apart from this pigment, carotinoids include the xanthophylls, the yellow pigment of old leaves and of ripe fruit. In animal organisms carotene is transformed into Vitamin A. III, 16, 25, 57.

Carotid sinus: part of the internal carotid artery, the wall of which encloses nerve endings that are sensitive to variations in pressure of arterial blood. V, 95; VI, 81.

Carpel: in the higher plants, a modified leaf that forms the wall of the pistil or the flower. III, 49, 64, 66; mi.

Cartilage: a resistant, elastic tissue, formed by cells disseminated in a ground substance or matrix and of fibres the nature of which determines that of the cartilage itself. Cartilage may be of three types: *hyaline cartilage* and *fibrous cartilage* made of collagen fibres, and *elastic cartilage* made of elastic fibres. Cartilage is abundant in some fish (skate and others) and in other vertibrates it may be replaced by bone tissue. In mammals it only exists as a bony articular surface or in the form of rings. I, 61; V, 20; mi.

Caseum: yellowish-grey matter, of the consistency of rubber, which appears in the tubercles during tuberculosis and tends to replace living matter. VI, 9; VII, 40, 41.

Castration, foetal: experimental removal of ovary or of testes of the foetus in order to study the early influence of sexual hormones on the development of the genital organs. I, 150, 151.

Castration, plant: removal of the stamens of a plant; this allows autofertilization to be avoided and enables experimental crossing to be carried out. III, 131, 132.

Catabolism: the totality of reactions of cell respiration resulting in the transformation of living matter and cell reserves into waste matter with a low level of energy. Catabolic reactions lead to the liberation of energy; the final products are carbon dioxide (CO_2) and oxygen (O_2). I, 39; VII, 62.

Cataract: an ocular affection leading to opacity of the lens of the eye or of its capsule. VI, 51, 142, 143, 145.

Catheter: a metallic rod, hollow or solid, used to explore an orifice or a duct, notably the urethra. See also Cardiac catheter. V, 93.

Cave-dwelling animal: an animal that lives in underground caves. Such an environment involves a certain number of biological adaptations to the special conditions of underground life, particularly the absence of light and the constancy of temperature, which may be very low or very high. II, 57.

Cell: the structural unit of all living matter. The cell is composed of two distinct parts: the nucleus in the centre, and the cytoplasm surrounding it. It is delimited and separated from the external environment by a membrane that plays a determining part in the life of the cell by selecting the substances that come from the environment and constitute the nourishment of the cell. In all plants and in certain microbes, a second rigid membrane covers the first.

In the cytoplasm certain bodes are to be observed (mitochondria, Golgi bodies, vacuoles, which are pulsatile or digestive, etc.). The physiological functions of these are specific, especially those of the mitochondria. The nucleus, delimited by a fine membrane, contains the chromosomes, mainly made up of DNA, which initiate cell divisions and carry the hereditary characters.

All living cells multiply by segmentation of the nucleus and the cytoplasm; this process is called mitosis, from which two daughter cells result.

Certain organisms consist of only a single cell: these are unicellular organisms, for instance, amoeba and paramecium. The others, multicellular organisms, are formed by agglomerations of cells grouped in tissues and organs. I, 40, 42, 58-62, 64, 65, 67-69, 128; IV, 18, 23. H.

Cell division: the fundamental mechanism of growth and multiplication of living organisms. Cell division may be carried out in three different ways: direct division, or amitosis; indirect equational division, or mitosis; reductional indirect division, or meiosis. In amitosis the cell divides without any previous rearrangement of the nuclear elements by a simple constriction of the cytoplasm. This method of cell division, generally considered to be primitive, is not very widespread. It is to be observed, for instance, in leucocytes and in certain connective tissue cells, the fibroblasts. Indirect division is more complex. Also called karyokinesis (from the Green *karyon:* nucleus; and *kinesis:* movement), it entails important rearrangements of the nuclear structure, in particular the appearance of chromosomes. During mitosis, as a result of longitudinal cleavage, or splitting into two of the chromosomes, the number of chromosomes of each daughter cell will be identical to that of the chromosomes of the mother cell. Mitosis is the method of multiplication of diploid plant cells of the organism (soma) which contain two identical assortments of chromosomes ($2n$ chromosomes). Mitosis takes place in four stages: prophase, metaphase, anaphase, telophase. (1) During the prophase the nuclear membrane is dissolved and long chromosome filaments appear, already doubled except at one point, the centromere. The filaments are strongly spiralled and each takes on a characteristic shape. While the nuclear membrane is disappearing, a special formation, the achromatic spindle, appears, consisting of fibrils. (2) During the metaphase, the chromosomes are arranged on the equator of the achromatic spindle; each of them becomes attached to a fibril by its centromere: this is the equatorial plate stage. (3) During the anaphase the two parallel filaments of each chromosome separate and migrate towards one or other of the extremities, ie, the poles of the achromatic spindle. It is generally during the course of this migration that each chromosome doubles again, the two filaments remaining joined until the subsequent mitosis. (4) Finally, during the telophase, the chromosomes lose their spiral shape and become almost invisible and the nuclear membranes round the two new nuclei are formed. Nuclear division has been accomplished. It is then that there occurs the division of the cytoplasm by cleavage or constriction. Meiosis which, beginning with a diploid cell, gives rise to haploid reproductive cells, or gametes, consists of two successive divisions, the one reductional, the other equational. During the prophase of the first division, two chromosomes of the same pair become closely paired: this is what is called synapsis. After the occurrence of synapsis, each of the coupled chromosomes doubles into two filaments that remain attached by their centromere: the four parallel filaments form a tetrad. During the course of this an exchange of chromosomic matter is produced by crossing over. This stage of meiosis is of great importance in the transmission of hereditary characters (see Heredity). During the metaphase, the tetrads are arranged on the achromatic spindle (equatorial plate) and during the anaphase, each doubled chromosome migrates towards one of the poles of the achromatic spindle. After the telophase of this division there immediately follows the equational division. The chromosomes are already split during the course of this normal mitosis. Each element of each tetrad is found in one of the four daughter haploid cells. Meiosis is the mechanism in cytology that permits organisms with sexual reproduction to preserve a constant number of chromosomes: during the course of fertilization a male haploid gamete (n chromosomes) joins with a female haploid gamete to form a diploid organism. In certain cases, either naturally or artificially, the mechanism of cell division may be disturbed and there then follows a change in the number of chromosomes which may be multiplied by 2, 4, etc.: this is called polyploidy and is to be observed especially in certain cultivated plants. I, 27, 62, 63-65, 68, 115, 116, 117, 143, 145; II, 16, 17; III, 17, 56, 57, 62, 64, 66; VII, 30, 90, 95; mi (Mitosis and Meiosis).

Cell exchange: exchanges of chemical substances between the cytoplasm and the internal environment. These exchanges allow for the elimination of waste matter of metabolism and the absorption of the subtrates necessary for cell permeability. V, 41-47.

Cellular inclusions: visible inclusions in cytoplasm or nucleus of cells parasitized by viruses (eg, the Negri bodies in nerve cells infected by the virus of rabies). IV, 90.

Cellulose: an organic substance of the glucoside group (polysaccharides) which has very long fibres and constitutes the structure of the cell walls of plants. Cellulose cannot be attacked by digestive enzymes of most animals, but thanks to bacteria in the digestive system of herbivores it can be digested by them, as it can by termites among invertebrates. III, 150.

Cellulose membrane: a membrane that characterizes plant cells where it also functions as a plasma membrane. The mechanical properties of cellulose make the cells rigid and serve the function of intercellular cement. It is formed of cellulose and pectic compounds. III, 11.

Cell-wall: the envelope that delimits the cell in bacteria and plants, generally thick and strong. The cell wall is made up of polysaccharides, lipids and proteins. III, 76; IV, 24-26, 63, 118.

Centre, organizer: see Organizer.

Centripetales: sensitive fibres that transmit nerve impulses from an organ or apparatus towards a nerve centre. VII, 29.

Cephalisation: a phenomenon by which, during the course of evolution of animals, the anterior part is differentiated and becomes a head with sensory and feeding functions. Cephalization began in the lower invertebrates. I, 87.

Cephalocaudal axis: the longitudinal axis of the body. It is round this that the organism, during the course of embryogenesis, produces bilateral symmetry. I, 131.

Cephalochordates: an intermediate subbranch between the invertebrates and the vertebrates, represented by a single species, the *Amphioxus*. II, 19.

Cephalopods: the most highly organized class of molluscs. They possess tentacles covered with suckers and large eyes comparable with those of vertebrates. The venous system of squids and octopuses is well developed; among these molluscs the ganglia constitute a true brain protected by a cartilagenous capsule; their shells vary considerably. I, 18, 20, 154; II, 67.

Ceratites: fossil cephalopods of the tertiary era. II, 28.

Ceratodus: a primitive fish in the rivers of the east coast of Australia. Possessing lungs and gills, this fish breathes on the surface when oxygen is lacking in the water. It is a panchronic animal of which fossilized dental remains were known before the living fish itself was discovered. II, 15, 17, 28.

Cercaria: the larval form of the schistosome, which lives in water and in this stage pierces the skin and enters the venous system. VII, 78; mi.

Cerebellum: that part of the brain situated behind the cerebral hemispheres above the medulla. The cerebellum plays a part in balancing and in the regulation of movement and muscle tone. V, 60; VII, 55; mi.

Cerebral cortex: a cellular layer 2 or 3 mm thick which covers the cerebral hemispheres. The cortex is essentially formed of grey matter. In man it includes six different layers of neurones. See Brain; Cerebrum, V, 69, 70, 73, 75-81, 83, 84, 86, 90, 101, 111; VII, 54, 58, 64, 130; mi.

Cerebral ganglia: in invertebrates this term is applied to the small cell masses situated dorsally in the head and forming an agglomeration of cells and nerve fibres. The functions of control and integration of the organism of these cerebral ganglia in insects and in cephalopods often make them comparable to a brain. II, 45; mi.

Cerebral hemisphere: the foremost part of the right and left halves of the cerebrum V, 60, 68, 86, 87, 137.

Cerebral peduncule: the white nerve tracts visible on the anterior face of the brain-stem, joining the diencephalon to the annular protruberance and constituted by the ventral portion of the mid-brain or mesencephalon. These tracts consist mostly of fibres of the pyramidal motor-pathways. V, 60.

Cerebro-spinal axis: the nervous system formed by the brain and the spinal cord. I, 135.

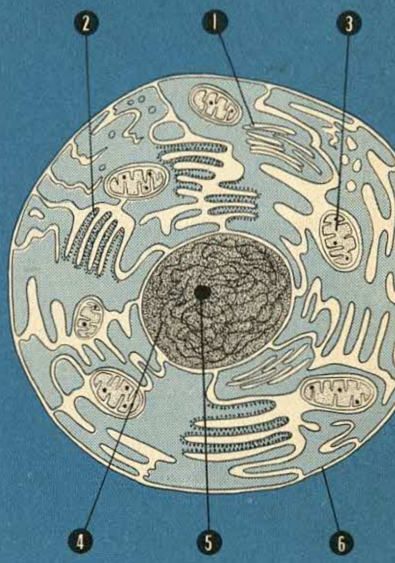
Cerebro-spinal fluid: a fluid filling the space between the layers of the arachnoid membrane and the pia mater (meninges) that forms a kind of liquid protective cushion round the brain and the spinal cord. VII, 34.

Cerebrum: a voluminous nerve centre that fills the cavity of the skull. This term designates the anterior part of the brain as opposed to the cerebellum and the medulla oblongata. The cerebrum is composed of two cerebral hemispheres linked together by the corpus callosum and the striate bodies situated in the centre of the cerebral hemispheres. The base of the brain includes the diencephalon with the thalamus, the hypothalamus, and the third ventricle. The hemispheres are made up of the cerebral cortex or grey matter, and inner white matter. During embryogenesis the anterior part of the neural tube divides into three vesicles, of which the anterior part later turns into the telencephalon. This development is identical in all vertebrates, but during the course of evolution a more and more accentuated development of the cerebral hemispheres took place, culminating in the brain of man. The fissures and the numerous convolutions of the cerebral hemispheres delimit a number of lobes, the frontal, parietal, temporal, and occipital, in which have been localized the various sensory and motor activities. The cerebral cortex as a whole constitutes the centre of mental activities, memory and consciousness. According to recent research, alertness and sleep are localized in a specialized part of the brain, the rhinencephalon, situated in the internal central part of each cerebral hemisphere. An increasingly important role is played by the reticular formation, which is concerned with coordination and regulation, the functions of which have been known for some years. Physiological activity of nerve cells is recorded by electroencephalography. The curves recorded by this means give information on the state of excitation or of rest of the neurones, the alpha and beta rhythms. Anomalies in these curves give indications of various brain diseases, and of disorders of the nervous system, such as tumours, epilepsy, or schizophrenia. To reduce or suppress neurological disturbances, the technique of neurosurgery is used, namely, resection of part of the brain for the operation of tumours, or psychosurgery, such as lobotomy and leucotomy. V, 13, 60, 68, 69-74, 98, 100; II, 20; mi.

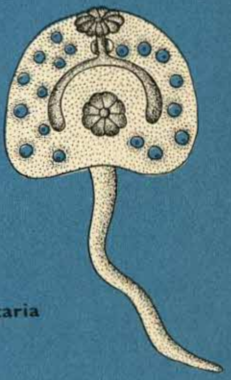
Chelating agent: a compound that fixes divalent and trivalent cations. Ethylene diamine tetracetic acid (EDTA) is an example. By fixing the Ca^{++} and Mg^{++} ions, it is used in dissociating the cells of a tissue culture. The expression 'chelating agent' is derived from the resemblance of this method of chemical action to the action of the claws—or chelaes—of a crustacean. I, 75, 76; IV, 46, 47.

Chemoprophylaxis: the use of chemical substances with the aim of preventing the appearance of a disease. VI, 46.

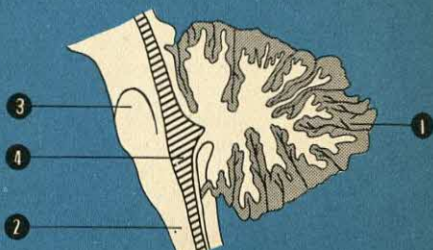
Chemoreceptors: sense organs affected by chemical excitation; for example, the



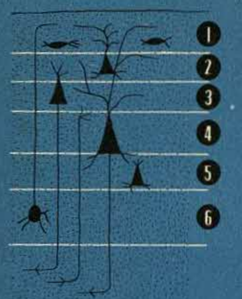
Cell
1. Golgi body. 2. Endoplasmic reticulum (with microsomes). 3. Mitochondria. 4. Nucleus. 5. Nucleolus. 6. Plasma membrane.



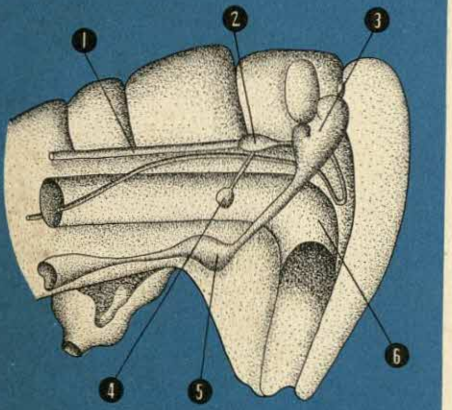
Cercaria



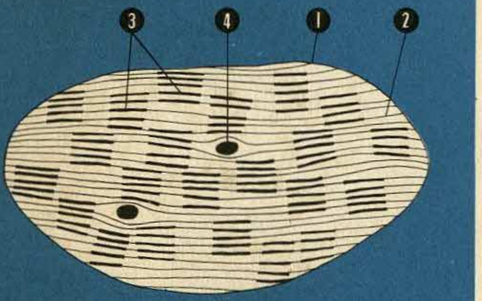
Cerebellum
1. Cerebellum. 2. Medulla oblongata. 3. Pons Varoli. 4. Fourth ventricle.



Cerebral cortex
The numbers represent six layers of neurones in the cortex.



Cerebral ganglion (insect)
1. Dorsal vessel. 2. Corpora cardiaca. 3. Cerebral ganglia. 4. Corpora allata. 5. Suboesophageal ganglion. 6. Digestive tract.



Chloroplast (of maize)
Detailed structure (electron microscope). 1. Membrane. 2. Stroma. 3. Grana. 4. Globule of lipid material.

organs of taste and of smell. II, 71, 72; V, 95.

Chemosynthesis: a biological mechanism by means of which, from the energy derived from certain chemical reactions, some groups of bacteria can synthesise substances from inorganic matter, starting from carbon dioxide in the atmosphere. Chemosynthesis, in contradistinction to photosynthesis, does not require the intervention of light; it may be summarized in two coupled chemical reactions, the one producing energy, the other leading to the formation of glucosides, absorbing the energy thus liberated. Usually the yield of chemosynthesis is very low. Chemosynthetic bacteria, such as nitrifying bacteria, sulphur bacteria, and iron bacteria, are autotrophic organisms, as in their way are plants possessing chlorophyll. With regard to the general picture of synthesis of glycosides, chemosynthesis only plays a very minor part, but it is of definite biological importance; the question that remains to be answered is whether, during the course of evolution of living beings, it preceded photosynthesis or not. III, 12, 23, 24.

Chemotactic attraction: an attraction caused at a distance by diffusion of a specific chemical substance. I, 114.

Chemotactism: sensitivity of a living organ to a chemical substance. Positive chemotactism indicates that the organism displaces itself towards the substance; negative chemotactism means the opposite. III, 66; IV, 114, 115.

Chemotherapy: the treatment of diseases by means of chemical substances. Chemotherapy is a branch of therapeutics that is in a state of constant renewal and depends on the progress of pharmacology in particular and of chemistry in general, in the treatment of infectious diseases. Before the discovery of sulphonamides and antibiotics, the diseases that were amenable to chemotherapy were not very numerous; they included malaria (quinine), syphilis (mercury and bismuth), and sleeping sickness (organic compounds of arsenic and antimony). The sulphonamides, which are active against a great number of micro-organisms, constitute a group of organic substances derived from nitrogen and sulphur. In antibiotics chemotherapy has shown important developments. Most infectious diseases may be cured by wide-spectrum antibiotics, such as penicillin, chloramphenicol, streptomycin, and the tetracyclins. The field of chemotherapy has been considerably enlarged by the therapeutic use of chemical substances that have a normal physiological action, these being hormones, such as cortisone and insulin, vitamins in cases of dietary deficiency or as adjuvants (Vitamin C) in the cure of infectious conditions, anti-cancerous substances, especially for leukaemias, antimitotics, and antimetabolites, such as erysan and 6-mercaptopurine. In the treatment of neurological affections, tranquillizing substances are being used more and more in place of surgery (psychochemistry). VI, 28, 94; VII, 89, 90, 94, 95, 99, 101.

Chemurgy: the totality of activities that are directed to finding new outlets for new processes in the industrial transformation of agricultural products, particularly superfluous by-products of agricultural and food industries. III, 148.

Chicken-pox: an infectious disease caused by a virus which, after an incubation of fourteen days, is characterized by an eruption of small red spots in the centre of which there is a small pink vesicle like a dewdrop. These vesicles first become opalescent, then purulent, and lastly dry out. If the patient does not scratch, the eruption leaves no scars. VI, 23.

Chimera: a tissue, organ, or organism formed of cells derived from two individuals of different species. Chimeras are obtained by the culture of mixed tissues. I, 83; III, 80, 81, 134.

Chironomus: a Dipteran insect, closely related to mosquitoes, of which the larva is known as 'blood worm'. The salivary glands of this larva, with its giant chromosomes, constitute good material for the observation of chromosomes and the study of their constitution. I, 117; II, 57; V, 128.

Chitin: a nitrogenous organic substance which gives its consistency to the cuticle of insects and the carapace of crustaceans. II, 44.

Chlorella: a microscopic green alga present in fresh water. Chlorellas are shaped like small spheres a few microns in diameter. Their great capacity for photosynthesis enables them to be used in laboratory studies and industrial culture. *Chlorella vulgaris* is a classic case of symbosis with animals (amoeba, infusoria, and hydra). III, 25, 26, 28, 140.

Chlorolabe: a pigment present in the cells of the retina in the cones which selectively absorb green light radiations (according to Rushton). V, 110.

Chlorophyll: a characteristic green pigment of plants found especially in the cells of the leaves. It is concentrated in the chloroplasts in the form of dense clumps (or granas), and in its molecular structure (the tetrapyrrolic nucleus with a magnesium pattern), resembles haemoglobin of the blood. Chlorophyll is one of the main agents of photosynthesis; this enables the conversion of light energy into chemical energy to take place. I, 16; III, 16, 25, 26.

Chloroplast: an intracellular corpuscle of green leaves containing chlorophyll, and the seat of photosynthesis. The chloroplast has a complex structure, limited by a fine membrane and formed of fine parallel layers, condensed at certain points: these are the granas that contain chlorophyll. I, 125, 126; III, 16, 24-26, 76; IV, 92; mi.

Choanocytes: cells that are characteristic of sponges, of ovoid shape and supplied with a flagellum which beats inside a transparent cofarette. By phagocytosis the choanocytes absorb particles transported by the current caused by the movement of their flagella. I, 86, 88; mi (Sponges).

Cholecystography: radiography of the gall bladder and bile ducts after ingestion of an iodized substance opaque to X-rays; the iodine salts are eliminated by the bile and render the vesicle visible a few hours after absorption. VII, 28.

Cholera: a infectious disease caused by *Vibrio comma*, characterized by abundant diarrhoea followed by a watery discharge that leads to dehydration, a fall in arterial pressure and a fall in peripheral temperature. VI, 12, 23, 29; VII, 81.

Cholera vibrio: a comma-shaped bacterium that produces cholera. IV, 55, 85; VI, 19.

Cholesterol: a polycyclic carbon-atom organic substance derived from sterols. Cholesterol is present in all animal fats, bile, blood and liver, etc. It is the origin of most biliary calculi and atheromatous deposits. It is said to be the cause of atherosclerosis. V, 139; VI, 89, 91, 111; VIII, 14, 28, 62.

Chondriome: collectively, the cytoplasmic corpuscles of the cell, called chondriosomes or mitochondria. The chondriome plays an important part in cell metabolism. See Mitochondria. I, 58, 59, 128, 130; IV, 62; mi.

Chrondriosomes: see Mitochondria.

Chorda: see Notochord.

Chordates: groups of animals characterized by the existence of a skeletal axis between digestive tract and nervous system. Chordates are also called 'epineurian coelomates' (having an internal cavity and a dorsal nervous system). They are divided into four branches: Hemochordates (acorn worms), Tunicates (ascidians), Cephalochordates (amphioxus) and Craniates vertebrates). II, 18, 19, 20.

Chorion: a membrane attached to the embryo that covers both the amnion and the allantois. It is never of maternal origin in mammals. I, 32, 33.

Chorio-allantoic: a membrane formed by the fusion of the internal wall of the chorion and the external wall of the allantois (in the chick), constituted by an external ectodermic layer, an intermediate layer, and an internal endodermic layer. It is the main respiratory and excretory organ during incubation. In mammals this part of the embryo helps in the formation of the placenta and serves nutritional as well as respiratory, excretory and endocrine functiohs. The chorio-allantoic membrane of the chick embryo is used as a culture medium for numerous micro-organisms (bacteria and viruses). I, 32, 33.

Choroidal vessels: vessels situated in the choroid (a vascularized membrane of the eye situated between the retina and the sclerotic and continued forward into the iris). VII, 144.

Chromagogue function: a function of the liver that is intended to extract from the organism and excrete via the bile certain colouring substances introduced artificially into the blood.

Chromatic reduction: see Cell division.

Chromatin: a specific basophil substance of the cell nucleus that absorbs selectively on basic dyes. I, 146; II, 62; VII, 34, 35.

Chromatography: a technique based on the separation of different substances in a porous or absorbent medium. Each pure substance migrates a given, always constant, distance. In order to identify separated substances 'developers' are used that confer a characteristic coloration. This technique is much used in biochemistry. IV, 106, 110.

Chromoblastomycosis: epidermal mycosis characterized by an eruption of pustules, nodules and spots due to a fungus. VI, 64.

Chromogenesis: the ability of a cell or an organism to produce a coloured pigment. There are among bacteria a certain number of chromogenic species of which the coloration is specific, for example, *Serratia*, the colonies of which are violet, and *Psudomonas*, which are green. IV, 38.

Chromomeres: visible swellings of the filamentous chromosomes at certain stages of cell division (prophase and metaphase). The chromomeres for any given chromosome are of constant number and fixed position. It has been said that chromomeres are the rolled spiral segment of the chromoneme (Grassé). I, 117, 119.

Chromonema: a long thin spiral filament with small granules on it (chromomeres), constituting the chromosome. I, 117, 119.

Chromosome map: a map on which are indicated certain points that show the position on a chromosome of genes responsible for a particular character of an individual. I, 118, 119, 122, 123.

Chromosomes: essential elements of the nucleus of the cell, so called because they take up very strongly the cell stains used in histology. They are seen either in the form of a granular mass or as more or less long filaments, depending on the different phases of the cells (resting stage or division stage). The chromosomes, made up of DNA and special proteins (the histones), are the physical basis of the genes. Through these are transmitted hereditary characters. In each species, whether animal or plant—except for bacteria, which only possess one chromosome—the number of chromosomes, which can vary between some hundreds and two, is always even and specific. At the moment of fertilization, in species that reproduce sexually, the two chromosomes of the same pair couple, except for one pair, constituted by the sex chromosomes or heterochromosomes, which are different from one another and are responsible for the determination of sex. These heterochromosomes are usually called X and Y. In man and mammals, fish, amphibians, and numerous groups of invertebrates, the female sex carries a pair of X chromosomes, the masculine one X and one Y. In birds and reptiles it is the other way round. They cannot be seen when the nucleus is resting, but appear distinctly at the moment of cell division (mitosis). Each chromosome replicates itself by autoduplication and then, in a daughter cell, each chromonema carries the hereditary character of the species. Anomalies of division of chromosomes, arrest of duplication, translocation, fragmentation, etc., are the causes of chromosomic diseases, such as mongolism in man. This field of medical research, at the moment fast developing, may in the future, allow us to understand hereditary diseases and perhaps treat those which up to now have been incurable. I, 60, 62, 63-65, 119, 123, 124, 143; III, 16, 38, 64, 66, 132, 133, 134; IV, 32; VI, 128, 138, 139, 146, 147, 159; VII, 67, 90, 95, 96.

Chromosome matrix: a chromosome sheath or covering containing a helical chromonema. I, 117, 119.

Chytridia: a group of microscopic fungi, usually unicellular and for the most part parasites of algae. III, 48, 49.

Cicatrization: a complex phenomenon of regeneration when the skin or the epidermis is cut. Scar tissue, richer in fibres than normal skin, is less elastic. I, 100.

Cidaris: a sea urchin, originating as far back as the Carboniferous period. It lives on the sea bottom at about 60 or 100 metres, travels by means of tube-feet, and feeds on sponges and starfish. II, 25, 26.

Cilia: in unicellular organisms, extremely fine filaments that move rhythmically and ensure locomotion. In ciliated tissues of multicellular organisms, such as the bronchial mucosa or the intestinal mucosa, cilia ensure the spreading of a thin liquid layer over the surface of the cell. II, 74.

Cine-angiocardiography: see Angiography.

Cine-densigraphy: recording by photoelectric cells of lung movement or lung periodicity caused by distention and rhythmic restriction of the diameter of lung arterioles in the periphery of the lung. VII, 21.

Circulation: continuous directed rhythmical movement of a nourishing liquid, the blood, circulating through all parts of the organism. Circulation is regulated by periodic contractions of the heart muscle; its speed and condition depend on the differences of pressure that exist in the blood vessels of various parts of the body. In higher vertebrates, arterial blood of the left ventricle of the heart is sent to the organs and tissues in which, in the capillaries, it gives up its oxygen to the cells and is charged with carbon dioxide. The blood, having become venous, returns by means of the systematic circulation to the right side of the heart, from which it is pumped into the lungs, in which it gets rid of its carbon dioxide and assimilates oxygen by means of a respiratory pigment, haemoglobin. Having thus become arterial blood through the pulmonary circulation, it returns to the left side of the heart and the cycle begins again. Birds and mammals possess the most efficient and effective circulatory system, since venous circulation is totally separated from arterial circulation. A mixture of blood is not produced in man except in pathological cases (for instance, in the Fallot syndrome or persistant ductus Botalli), while in the majority of reptiles it is physiologically normal. In many invertebrates that possess a circulatory system, blood and lymph are often mixed and it is then spoken of as haemolymph. But, on the whole, whether in invertebrates or vertebrates, the composition of the circulating liquid is similar; in addition to mineral salts and dissolved organic molecules (such as glucose), the elements or cells of the blood have the same functions: phagocytosis and defence of the organism by means of white cells and transport of respiratory pigments by means of red cells. In the evolutionary scale of animals, the circulatory system appears with triploblastic animals. Its origin is to be found in the third embryonic layer, the mesoderm, which gives rise to the walls of vessels, the heart muscle, and blood cells. The circulatory system appears to have had, during the process of evolution, an importance which must not be underestimated: it has enabled marine animals to adapt themselves to dry conditions by taking with them their 'internal sea' and it answers to the requirements of a great complexity of anatomy: it is by means of the circulation that, even in higher animals that have remained in the sea, all the cells of an organism may enter into contact with the external environment which can supply them with food and respiratory requirements necessary for their survival. V, 12, 13, 91; VII, 24, 25, 59, 60.

Cirrhosis: the name given to a number of liver disorders, all of which have the common characteristic of fibrous proliferation accompanied by various modifications of the liver cells. Cirrhosis is often of alcoholic origin. VI, 73, 74, 110, 120, 140; VII, 29.

Claudication, intermittent: claudication, or limping, after a few minutes' walking is due to a number of causes. Ischaemic intermittent claudication results from a syndrome that occurs in arterial sclerosis and is due to damage to the arteries of the lower limbs. A painful swelling and stiffness in the legs forces one to stop walking: after a moment of rest these sensations disappear. Medullary intermittent claudication, a sensation of weight and stiffness that is not painful, may occur in one or both the lower limbs after a few minutes' walking, but disappears after rest; it is accompanied by exaggerated reflexes, leading after a more or less prolonged period to spasmodic paraplegia. It is a manifestation of the beginning of myelitis of a paraplegic nature, in particular syphilitic myelitis. VII, 130, 131.

Claviceps purpurea (or ergot of rye): an Ascomycete fungus, a parasite of grain cereals; it takes the place of the ovary and makes the flower sterile (parasitic castration). The ergot or sclerote formed by the fungus in place of the seed, contains among other substances ergosterol, which, under the influence of ultraviolet rays, is transformed into Vitamin D, and ergotamine, an alkaloid substance which acts on muscle-fibre contractions. IV, 147.

Clearance: the theoretical volume of blood that is entirely cleared of a substance by the kidney in one minute. The urinary flow being 120 cc per minute, the clearance would be 120 cc for a body or substance entirely excreted during the course of passage through the kidney (eg, inuline and mannitol). If only half the amount of a substance is eliminated during its passage through the kidney, the clearance is 120 cc divided by 2=60 cc. The clearance of substances excreted by the tubules is higher than 120 cc. V, 24, 26; VII, 26.

Climatron: a new form of phytotron in which various combinations of temperature and humidity may be obtained in an immense dome without separating walls. III, 98.

Climax: a type of plant population, practically stable, which is the result of the evolution of vegetation in a barren area occurring in any given region because of the nature of the terrain and the climate. III, 121.

Cloaca: the common orifice of the digestive and genital apertures in some lower vertebrates, notably amphibia, reptiles and birds. I, 147, 150.

Clone: the sum of living beings derived from the same individual by vegetative multiplication. III, 36, 38, 66, 67, 131, 132.

Clostridia: bacteria characterized by a central or sub-terminal spore that deforms the bacterial body. Among the numerous species of clostridia, some are pathogenic (*Cl. botulinum*, responsible for botulism; *Cl. septicum*; *Cl. tetani*, etc.). IV, 18, 70, 72, 84.

Coagulation: a phenomenon in which an organic fluid such as blood or milk becomes a solid mass or coagulum and exudes a transparent liquid (serum). The coagulation of blood, which leads to the formation of a clot, is a very complex phenomenon, and as well as platelets and fibrin, at least a dozen enzymes are concerned, and also some mineral elements (calcium). V, 35-37; VI, 15, 111, 132; VII, 96.

Coalescence: the adhesion of two surfaces in contact (scarring, or pathological adhesions). The term is used in particular of cardiac valves, such as mitral, aortic and tricuspid valves; in such a case, perfect adhesion enables the organ to function properly; incomplete coalescence of the valves leads to blood regurgitation which in clinical terms is heard as a 'murmur'. VII, 126.

Coadaptation: the replacement of a displaced organ and, by extension, adapting two complementary organs to each other. II, 34.

Coarctation of the aortic isthmus: a congenital stenosis of the isthmus of the aorta. VII, 119.

Cocci: bacteria of spherical shape. Cocci may be found as separate or isolated elements, but more often they are united in pairs (diplococci) or in chains of varying lengths (streptococci) or in irregular clumps (staphylococci). IV, 51.

Coccidio-iodo-mycosis: an illness observed in California in the Valley of San Joaquin, characterized by a period of fever for some days (San Joaquin fever) that affects the lungs and is caused by a fungus (*Coccidioides immitis*) the spores of which are inhaled with dust. VI, 14.

Coccoids: unicellular algae which do not swim, consisting of a coated cell which is often round or oval, like a seed. III, 48.

Cochlea: part of the internal ear containing the auditory ciliary cells. V, 115, 116, 117, 119; mi.

Cockroach: an insect of the Orthoptera order, common in warehouses or cellars. From the palaeontological point of view, the cockroach is a remarkable example of a panchronic animal; that is to say, it has evolved very little during the course of long geological periods. II, 32, 34.

Coelacanth: a well-known example of a 'living fossil' fish. Before the discovery of living specimens near the coasts of South Africa, it was known only as a fossil. This species, the origin of which goes back three hundred million years, is a remarkable example of panchronic animal. I, 18, 19; II, 24, 25, 27.

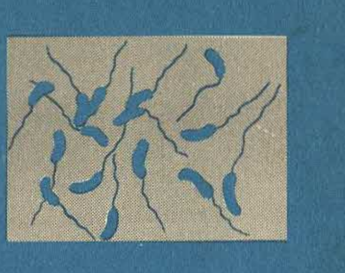
Coelom (or main body cavity): the sum of the spaces that arise in mesodermic tissues during the course of embryonic development of multicellular triploblastic animals. The coelom, arranged in regular segments in certain arthropods (insects and annelids), may disappear in the adult stage in certain groups; it is nevertheless a major factor in the determination of shape. II, 17.

Coenocyte: a structure in which many cell nuclei are found unseparated by membranes. III, 78, 79.

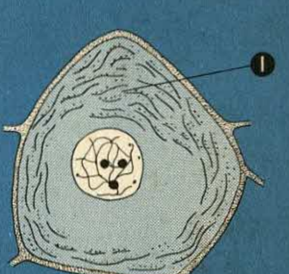
Co-enzyme: the hydrosoluble and thermostable part of the enzyme. A co-enzyme may be either a vitamin or an organic metallic substance, or a simple metallic ion, for example, Ca^{++}. V, 50, 51.

Cold, common: an acute catarrh of the nasal and ocular mucosa. It occurs periodically in certain individuals during the flowering season and may be considered then as the equivalent of asthma or the disorder known as hay fever or 'spasmodic coryza', q.v. By extension, the term is also applied to any seasonal rhinopharyngeal infection, whether it be bacterial, viral or allergic. VI, 22, 23, 31; VII, 66, 70.

Coleoptile: covering of the embryo of seeds of cereals and grasses. In developing, the embryo pierces the coleoptile, which

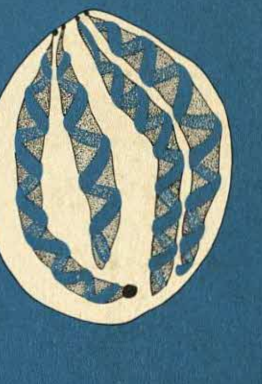


Cholera vibrio

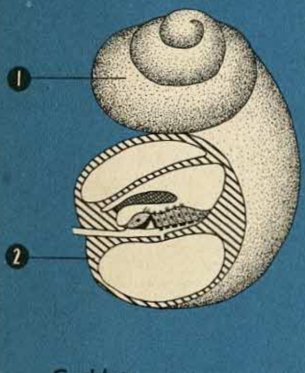


Chondriome

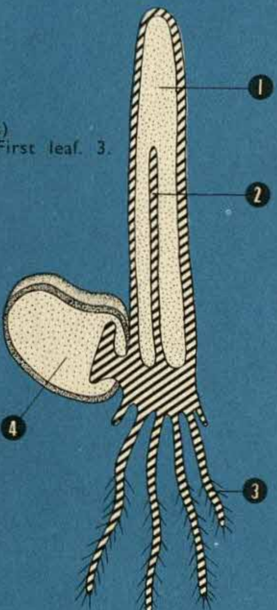
1. Chondriosomes.



Chromosomes (flagellate, Trichonympha)
Beginning of prophase.



Cochlea
1. Cochlea. 2. Section showing the organ of Corti.



Coleoptile (of oats)
1. Coleoptile. 2. First leaf. 3. Roots. 4. Seed.

Collembola

remains at the base of the stem like a small spur above the first node. III, 83; mi.

Colibacillosis: a disease caused by Escherichia coli, usually found in the intestine, where it lives in symbiosis. It is not normally pathogenic but may acquire great virulence, causing a number of disorders of the intestinal and urinary systems. VII, 88.

Collagen: a fibrous protein substance of connective tissue. Collagen fibres form the basis of tendons and cartilage and interstitial tissue. The hardening of collagen fibres is the cause of most of the symptoms of sclerosis. V, 136, 139; VI, 88, 89, 114, 115.

Collagen diseases: a group of diseases of varied appearance: rheumatoid arthritis, generalized scleroderma, polyarthritis nodosa, lupus erythematosis, all of which have a common characteristic—an affection or disorder of collagen (an interstitial substance of connective tissue) which is undergoing fibrinoid degeneration, following allergic or immunological reactions that are not, as yet, properly understood. VII, 65.

Collapse therapy: see Pneumothorax. VI, 26.

Collembola: a very primitive order of insects without wings, living in the soil. The collembola are panchronic animals. II, 25, 26, 36, 37; mi.

Colloid: a substance in suspension, or emulsion in a liquid medium, of which the constituent elements are large molecules or micellae, which cannot dissolve in the liquid medium or be affected by gravity. Colloids are often present in the form of gels with a viscous consistency which flow very slowly. Cytoplasm of cells is essentially made up of protein colloid gel. I, 37, 38, 38; III, 16.

Colony, bacterial: a bacterial mass resulting from successive multiplications of a strain of bacteria cultivated in a solid culture medium (gel). Bacterial colonies composed of several thousand millions of bacteria are normally visible to the naked eye. Their characteristic aspect is often sufficient to identify the nature of the micro-organism. IV, 45, 54.

Colony, R. type: a form of bacterium, the colonies of which have a granular aspect. The R forms (R being an abbreviation of 'rough') generally come from permutations of S colonies that have lost their virulence. IV, 38, 65.

Colony, S. type: a bacterial colony that has a smooth appearance (hence the use of the initial S). The transformation of an S colony to an R colony appears very frequently in a culture and is accompanied by loss of the bacteria's virulence. IV, 36, 38.

Colour synthesis (or trichromatic synthesis): a technique of colorimetry by which any colour is obtained with the colours red, green and blue. V, 107, 108.

Columella: a straight hollow tube that forms the axis of the cochlea in the internal ear of vertebrates. V, 115, 117, 118.

Coma: loss of bodily co-ordinating functions (profound stupor, with loss of awareness, feeling, and movement) but with conservation of the vegetative functions of life, circulation and respiration. There are many causes of this condition and coma may be classified as: traumatic, neurological, vascular, toxic and metabolic. Depth of coma is variable and may be light or deep. VII, 17.

Combined serum and toxoid therapy: in the treatment of diphtheria or tetanus, a mixed treatment that includes both injections of toxoid and an injection of serum made in a different place. This treatment was begun in Britain before 1930 and has the advantage of inducing an instantaneous passive immunity, although a transitory one, provided by the serum, and an active immunity conferred by the toxoid; such immunity is durable and protects the patient from relapse. VII, 82.

Commissurotomy: section of the commissure of the two adherant mitral valves (mitral stenosis). This is effected by a special instrument or by simple digital dilation of the orifice. VII, 126.

Complement fixation: the normal thermolabile and non-specific constituent of blood that forms part of the fluid defence factors against bacteria. IV, 129.

Complex cycle: a cycle of development and reproduction of certain invertebrates of which the parasite larvae, in order to reach the adult stage, need to pass through a number of different hosts, or to live in an environment of differential chemical composition. II, 53, 54.

Conditioned reflex: see Conditioning.

Conditioning: in psychology, the establishment of a conditioned reflex. The first conditioning experiments go back to Pavlov, who studied the salivary reflexes of the dog. Conditioning consists, in such a case, of causing the animal to associate the sound of a bell with the presentation of food, thus making it salivate. After a certain number of repetitions of the coupling of food (unconditioned stimulus) and sound (conditioned stimulus) the conditioned stimulus by itself (sound of the bell) triggers the conditioned reflex of salivation. This conditioning is called type I conditioning. V, 72, 79, 150; VI, 89; VII, 64.

Cone: a photoreceptor element of the retina which exists only in certain vertebrates. The cones, much less numerous than rods, are concentrated in a region of the retina, the fovea, and play a part in colour vision. V, 102, 103, 104, 106, 110, 111.

Congenital: a disorder or malformation that appears during foetal life and manifests itself from birth onwards. VI, 6, 117.

Connective tissue: tissue that covers and connects organs. Originating in the embryonic mesenchyme, this tissue is formed of stellate cells which are surrounded by a gelatinous ground substance crossed by fibres. The dermis, cartilage, bone tissue and blood are all connective tissues in which the cells are slightly differentiated and the ground substance is different. One of the essential properties of a connective tissue is its ability to replace another. I, 61, 64, 66, 67; VI, 114.

Conjugation: a form of sexual reproduction observed in Paramecia. Following a period of multiplication by fission (vegetative phase), two paramecia join together and exchange part of their nuclear material (conjugation phase). I, 103, 104, 105; II, 19, 31; mi.

Consanguineous strain: a strain that has been maintained by brother-sister matings for at least twenty consecutive generations. IV, 143, 144.

Consanguinity: derived from the mating of two organisms that have a certain degree of consanguinity; that is to say, they have among their ancestors one or more in common. II, 143, 144.

Conspecificity: belonging to the same species. II, 84.

Contagion: the material cause of contraction of an infectious disease. In the case of tuberculosis, contagion occurs mainly by expectoration. In sputum, the tubercle bacilli keep their vitality for some weeks or even months. VI, 27.

Contractures, tetanus: violent and continuous contractions of the muscles, caused usually by the toxins of the tetanus bacillus (*Clostridium tetani*). In man, this contracture is first visible in the muscles of the jaw (trismus). Tetanic contractures, analogous to those of tetanus, may also be observed in young children following over-feeding with vitamin D, or in alcalosis or bad functioning of the parathyroid gland. IV, 82, 83.

Contrast substances: substances that are opaque to X-rays (barium, lipiodol, iodides of sodium) or transparent (air) that enable observation of certain natural cavities or channels to be made, by contrast with their surrounding tissue. VII, 11.

Convergence: a fortuitous resemblance produced in physical or physiological characteristics of individuals of different species. Convergence may show itself in the simple external appearance, eg, the general shape of the body and the presence of a dorsal fin in sharks (selachians), ichthyosaurs (extinct reptiles) and porpoises (cetaceans), or in organic structure (as in the convergent adaptation of the frog, the crocodile, and the hippopotamus, in which only the nostril and eye emerge from the water when they swim), and in living beings not belonging to the same axonomic group. I, 85; II, 35, 66, 122, 124.

Conversion: the simultaneous acquisition by a bacterium of a new hereditary character and the power of lysogeny. Conversion is a particular case of transduction; here, the bacteriophage carries from one bacterial line to another the 'lysogen' character (the ability to be host to a virus without being lysed) at the same time as any other character. This phenomenon, which is fairly rare, has been observed in diphtheria and typhoid bacilli. IV, 108, 109.

Convoluted tubule: the beginning of the urinary tubule, approximately 20 millimetres in length (see Kidney). V, 21.

Cooley's disease: also called Mediterranean anaemia or thalassaemia, a form of haemolytic anaemia occurring in the first year of life, involving a reduction in the number and a change of shape of the red cells; also skeletal changes, especially in the ossification of the skull and the long bones. A congenital disorder, transmitted as a dominant character, it is due to the persistence of foetal haemoglobin (HbF). In homozygote subjects, haemoglobin F reaches 60 per cent. Survival of sufferers beyond puberty is rare. In minor thalassaemia, and where the level of haemoglobin F is lower, prolonged survival is possible. I, 155, 156; VI, 82.

Coprins: Basidiomycete fungi that grow on manure. Coprins show a phenomenon of heterothallia, that is to say, sexual differentiation of the mycelia derived from two different spores. Each mycelium that comes from a spore (primary mycelium), is incapable by itself of producing spores; the union of two mycelia, on the other hand, will form a secondary mycelium on which the basidia will develop. III, 17, 59, 60.

Coprophil (or coprophage): any living animal or plant that lives on excrement. In the plant world there are coprophil fungi; in the animal world there is a coleopter—an insect (*Coprophilus striatulus*) which feeds on faecal matter. III, 58.

Cormophytes: plants provided with a corm; that is to say, a vegetative apparatus carrying stems with leaves, at least in the early stages of life. Cormophytes are divided into those without flowers (Cryptogams: mosses and ferns) and those with flowers (Phanerogams: dahlias, willows). III, 46, 47, 48, 49.

Coronary artery: the artery that supplies the cardiac muscle. The two coronary arteries, left and right, start at the beginning of the aorta. Atherosclerosis of a coronary artery is the cause of chest angina; obstruction of one of these arteries by a blood clot causes myocardial infarction. V, 13.

Corpora allata: small endocrine glands of insects, two in number, situated in the head behind the cerebral ganglia. These glands secrete a hormone called juvenile hormone, the effect of which is to prevent metamorphosis, the transformation of the insect into an adult. If the corpora allata are excised from the larva, it will turn into an adult whatever its larval stage. II, 45, 46.

Corpora quadrigemina: symmetrical brain structures, four in number, situated dorsally behind the cerebral hemispheres and formed by a nucleus of grey matter surrounded by a thin layer of white matter. The anterior tubercules are on the optic pathway, the posterior ones on the auditory pathways. V, 68.

Cor pulmonale: see Pulmonary heart.

Corpus callosum: in the brain of mammals, a thick layer of white matter joining the two cerebral hemispheres. V, 73, 86, 87.

Corpus luteum: a small internal secretion gland which forms in the ovary in a female mammal each time that a ripe ovum (in Graafian follicle) detaches itself from the ovary and passes into the uterus. The cells of the corpus luteum secrete a yellow pigment of a lipid nature, lutein. If the ovum has not been fertilized, the corpus luteum is reabsorbed; if it is fertilized, the corpus luteum will persist during the whole of gestation. V, 57, 58; VI, 103; VII, 14, 35; mi (Ovary).

Corpus striatum (striated body): a structure comprising the three nuclei of the brain (the caudate nucleus, the lenticular nucleus and the thalamus). The striated body controls a certain number of automatic behaviour mechanisms of the body; it is very important in birds. V, 86.

Corti, organ of: in the internal ear, the sensory structures of the cochlea that transform mechanical vibrations caused by sound waves into nerve impulses that proceed to the auditory centres. V, 118.

Cortical layers: superposed layers of nerve cells of grey matter in each cerebral hemisphere of the brain of mammals. There are six layers in all, distinguishable from each other by their thickness as well as their form and the abundance of the constituent nerve cells. V, 69, 70, 73.

Cortisone: a hormone secreted by the adrenal cortex. Cortisone is a corticosteroid. Its anti-inflammatory properties enable it to be used in treatment for acute rheumatism, arthritis, and certain conditions of hypersensitivity. V, 42, 46, 52, 54, 55; VI, 27, 33, 34, 102, 116, 134; VII, 62, 68, 98, 99.

Coryza: acute inflammation or chronic inflammation of the mucosa of the nasal passages, of bacterial origin or caused by viruses or allergies. Spasmodic coryza is the scientific name for hay fever. VI, 54, 55; VII, 66.

Cotyledon: an organ in the form of a thick leaf forming part of the seed of higher plants. Cotyledons contain reserves such as starch and fat. The presence of one or two cotyledons differentiates two classes in the Angiosperms. III, passim.

Coumarin: a substance found in numerous plants (eg, clover, balm and tonka bean) in the form of a heteroside. It is an anticoagulant widely used in treatment (eg, in phlebitis and myocardial infarction). It is an anti-vitamin K. V, 37; VII, 131.

Cowper's glands: small glands near the male sexual organs which secrete a fluid that forms part of the constitution of semen. I, 146, 149.

Coxsackie: an enterovirus, resembling the poliomyelitis virus; in certain conditions, which are not yet well established, it may attack nerve cells and cause paralysis. VIII, 11.

Crenotherapy: the therapeutic use of mineral waters. VII, 144-148.

Crossing: a method used in animal or plant biology consisting of fertilizing in a selective way certain individuals by others of the same species, or of a closely related species, and studying the results. Crossing has permitted us to discover and perfect the laws of genetics and to select varieties or strains possessing particular characters. I, 116, 117, 118.

Crossing-over: an exchange of hereditary factors (genes) between two chromosomes at the moment of reductional cell division (meiosis), giving rise to reproductive cells. Two homologous chromosomes at the stage of pairing may break and recombine, exchanging the broken fragments. This phenomenon, which is reminiscent of the recombination of chromosomes of bacteria, is of great importance in the transmission of hereditary character. I, 118; mi.

Crown-gall: a plant tumour caused by *Agrobacterium tumefaciens*, which shows in the form of galls on leaves. III, 36, 37.

Cryptogamia: a group of plants with hidden reproductive organs. The opposite of Phanerogamia or flowering plants. Algae, fungi, lichens, mosses and ferns are all Cryptogamia. III, 50.

Culture *in vitro*: a method of study used in experimental biology, anatomy, and pathology, consisting of conserving fragments of tissue or isolated cells in a nutritive medium outside the organism. The nutritive medium may be natural (lymph and plasma) or synthetic, such as Ringer's solution. The method of *in vitro* culture enables us to observe directly a number of physiological mechanisms, such as the differentiation of certain specialized cells (nerve and heart-muscle cells), cell damage due to certain diseases, in particular, virus infections; with synthetic medium cultures, this method permits us to determine the necessary constituents required for the survival of cells (eg, requirements in amino acids, vitamins, etc.). I, 34, 59, 60, 68-72, 80, 82, 84; II, 135; IV, 17, 52 et seq.

Curare: a poison extracted from a number of varieties of a tropical tree, *Strychnos* of Central and South America. Curare has a paralyzing action; it acts by inhibiting the motor end-plate of the muscles, that is to say, by interrupting the contact at the junction of the nerve and the muscle. In a person poisoned by curare, the respiratory muscles quickly cease to function and death ensues rapidly. V, 66, 67; VII, 57, 108.

Curietherapy: see Radium therapy.

Cuscuta: dodder, a parasite plant allied to the convolvulus. It is a complete parasite; that is, it can only develop if fixed on another plant into which it puts its suckers. III, 13.

Cuticle: in zoology, a coriaceous integument of arthropod invertebrate animals (crustaceans and insects) containing a special nitrogenous substance, chitin. In botany, an impermeable film covering the young stems and leaves of certain plants. II, 44, 59, 72.

Cyanocobalamin: see Vitamin B_{12}.

Cyanolabe: a pigment present in cells in cones of the retina; it is capable of absorbing blue radiation (a hypothesis of W. A. H. Rushton). V, 106.

Cyanophyceae (or blue algae): a group of very primitive algae characterized by their blue colour. These autotrophic algae feed exclusively on mineral substances. They are probably among the most ancient living organisms on this planet. I, 20.

Cyanosis: blue coloration of the skin produced by a disturbance of circulation, or by insufficient oxygenation of blood in the lungs. VII, 51, 124.

Cyclosis: the movement of cytoplasm of plant cells shown by a slow cyclic and regular movement round a cell nucleus. III, 12.

Cycloserine: an antibiotic with a small molecule capable of exercising a notable anti-tuberculosis effect. It has been used with some success in certain forms of human tuberculosis, but it is toxic to the nervous system and kidney, which limits its use considerably. VII, 87.

Cyclostomes: a class of aquatic animals, the representatives of which include the most primitive vertebrates; they owe their name to their round mouth which is shaped like a sucker. A typical one is the lamprey. II, 19.

Cylindraxis: a synonym of axon (q.v.). I, 88, 89.

Cyst (*anatomical*): a tumour, formed in an organ in a cavity filled with fluid or, very rarely, solid substance and of which the wall is not in circulatory exchange with the contents. VII, 23, 28, 34; (*botanical*): in plants, organ of dissemination derived from sexual reproduction and including a small number of cells (sometimes only one) and a thick cellulose membrane, resisting and protecting it from dryness and cold. III, 57.

Cystitis: acute or chronic inflammation of the bladder. VI, 71.

Cytochemistry: a method of studying the cell with the aim of determining the localization of various chemical substances in different parts of the cell itself, (nucleus, mitochondria, Golgi bodies, etc.). Cytochemistry involves observation at high magnifications, usually with the electron microscope. I, 50.

Cytochromes: pigments containing iron, present in the mitochondria of cells which play an essential part in the terminal stages of cell respiration, as well as in certain stages of photosynthesis. Cytochromes A, B and C, the formula of which is close to haemoglobin, are transporters of hydrogen (or rather, electrons): hydrogen extracted from its glucose molecule during the course of the processes of cellular respiration passes from one cytochrome to another, each time abandoning a little of its energy. III, 27; IV, 47, 48.

Cytology: the study of the properties of the cell. I, 59-78; III, 129, 130.

Cytology, exfoliative: cytological study of exfoliated cells from an organ in communication with the more easily accessible exterior (vagina, bronchi, stomach, and cyst punctures). VII, 34, 35.

Cytopathogen: a producer of lesions in the cytoplasm and in the cell generally. This term is employed for viruses and endocellular parasites. IV, 92, 93.

Cytophage: a genus of lower fungi (Schizomycetes) capable, because of a varied and rich enzyme apparatus, of developing on pure cellulose and of degrading it into its mineral constituent elements. IV, 69.

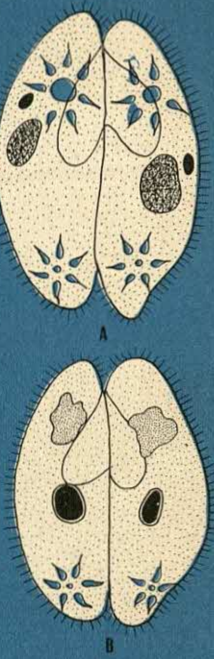
Cytophotometry: the microscopic study of cells, fixed or stained, by measuring quantitatively the concentration of a given substance by estimating the quantity of light absorbed by the cell preparation. The microscope is lit by monochromatic light and the image of the object to be measured is projected through a small orifice on to the cathode of a photographic magnifier; after amplification, the current produced by the latter is measured. I, 60.

Cytoplasm: a fundamental part of all living plant or animal cells (other than nuclei), composed essentially of proteins and containing a number of corpuscles with different functions (chondriosomes, vacuoles, lipid granulations, etc.). I, 51, 60, 61, 128; III, 12, 75; IV, 90.

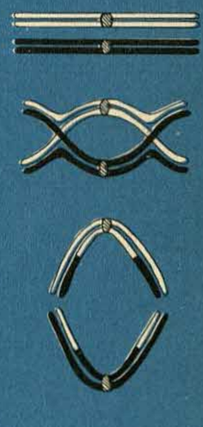
Cytoplasmic heredity: hereditary transmission of certain characters by means of certain bodies in the cytoplasm called plasmogenes. As contrasted with nuclear heredity transmitted by the genes of the chromosomes, cytoplasmic heredity is capricious and accidental. Only a few isolated cases are known (the kappa particles of paramecia and a 'sensitive' factor of *Drosophila*). I, 115, 125, 126.

D

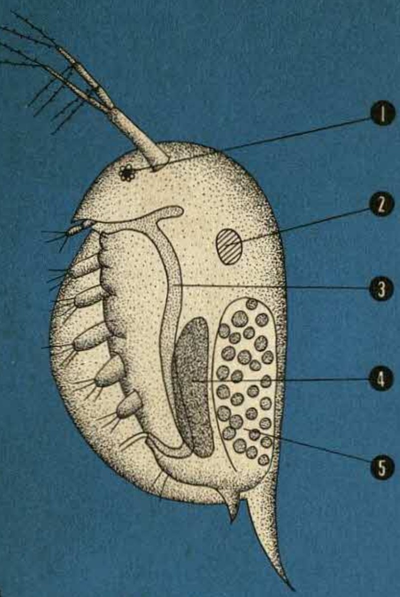
Daltonism: an anomaly of colour vision shown most often by a confusion between red and green. In Daltonian persons, red and yellow are seen as yellow and violet, and blue as blue. The gene responsible for this anomaly is carried by the X sex chromosome; Daltonism is thus a hereditary anomaly of recessive sex-linked character. V, III.



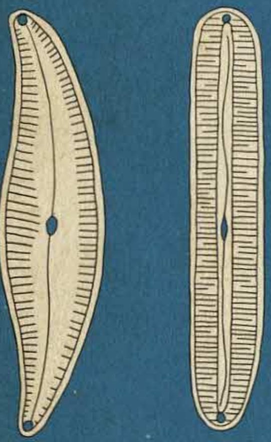
Conjugation
A. Beginning. B. Later stage.



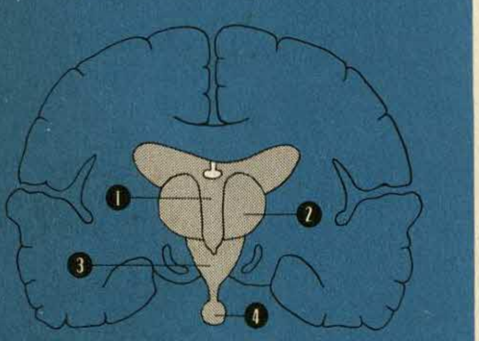
Crossing-over



Daphnia
1. Eye. 2. Heart. 3. Gut. 4. Gonad. 5. Brood pouch.



Diatoms



Diencephalon
1. Third ventricle. 2. Optic chiasma. 3. Hypothalamus. 4. Pituitary.

Daphnia (or water flea): a small crustacean (1 mm) common in fresh-water ponds, remarkable for its mode of reproduction: in the summer, reproduction is carried out without fertilization (parthenogenesis) and there are only female individuals, but the latest generation, produced at the beginning of the cold season, includes males and females which produce fertilized eggs. These resistant eggs pass the winter encysted and from them in spring there arise parthogenetic females. I, 27; II, 51; mi.

Dark reactions: those reactions of photosynthesis that do not require light. III, 26-28.

Dead space: part of the respiratory system constituted by the larynx, the trachea, the bronchi and the bronchioles, in which the volume of air that penetrates the lungs on each inspiration is not entirely used for respiration. In every 500 cc that constitute the used air, 150 to 170 remain in the dead space; in the calculation of the coefficient of ventilation, this figure must be subtracted from that of the circulating air. VII, 61.

Deiters' cells (or astrocytes): characteristic cells of the neuroglia. There may be distinguished—the oligodendroglia, globular cells with fine prolongations (grey and white matter); astrocytes of the grey matter, the cell body of which is angular; and astrocytes of the white matter, with the cell body in the shape of a star (spider cell).

Delirium tremens: acute delirium with hallucinations and agitation, appearing suddenly in a chronic alcoholic; delirium tremens is characterized by fever, profuse sweating and a special smell, considerable dehydration, and a permanent violent trembling. VI, 15.

Dendrites: cytoplasmic prolongations, generally numerous and branched, of the nerve-cell body. The nerve impulse goes in the opposite direction (that is to say, from the dendrite towards the cell body) to that of the axon (q.v.). The dentrites enter into contact by means of synapses with the axon terminations. V, 69.

Dendrochronology: a method of studying chronology, based on observation of the annual growth-rings of trees. Dendrochronology has been used for determining the age of trees (eg, the sequoias of California). Also, by the different thicknesses of the concentric layers, depending on rainfall, it is possible to retrace the climatic cycles of the past. III, 149.

Denitrification: the process of loss of nitrogen in the soil. Certain organisms, mostly anaerobes, in the soil, destroy the nitrites and the nitrates producing ammoniac and decompose it into nitrogen and hydrogen. The denitrifying bacteria are *Bacterium fluorescens* and *Bacillus denitrificans*. (see Nitrogen cycle). IV, 71.

Deoxycorticosterone: a hormone of the suprarenal cortex acting on the resorption of sodium chloride in the uriniferous tubules and on the distribution of potassium and sodium between protoplasm and the internal environment. V, 54; VI, 102.

Deoxyribonucleic acid (or DNA): see Nucleic acids.

Depressor reflex: a nerve situated in the neck, of which the endings are sensitive to fluctuations of arterial pressure in the aorta and the carotid sinus, and stimulation of which causes a sudden fall in this pressure. V, 92, 94, 95.

Dermatome: an apparatus for obtaining skin grafts of an exactly calibrated thickness (used mainly in plastic surgery). VII, 139.

Dermatomycosis: name given to skin diseases caused by fungi. VII, 88.

Dermatosis: any form of skin disease. VI, 71.

Desensitization: a therapeutic technique which aims at causing the disappearance of hypersensitivity reactions in certain individuals. Desensitization may be total or specific. In specific cases, a search is made for the antigen responsible for allergic reactions by means of a series of tests (skin reaction). This treatment should be used with care, because it is not without danger. VII, 71.

Desmidia: green unicellular algae of the Conjugatae group. III, 10.

Detection: discovery of a hidden disease through medical examinations of individuals who do not yet show any symptoms (eg, the beginnings of tuberculosis or of cancer). VI, 126, 127; VII, 17.

Determination: in embryology, a process of differentiation during which the future of an embryonic region or zone is fixed. I, 134, 135, 136, 139, 142.

Diabetes insipidus: a metabolic disturbance characterized by a marked increase in the excretion of urine. This illness is due to an insufficiency in the secretion of a pituitary hormone—vasopressin. V, 52.

Diabetes mellitus: a disease characterized by an increase in the level of glucose in the blood (hyperglycaemia). It shows itself by the elimination of glucose in the urine and its most characteristic sign is a marked loss of weight, due to the unbalancing of nitrogen assimilation. Diabetes mellitus results from deficient functioning of the islets of Langerhans of the pancreas, which secrete insulin. V, 52, 54, 72; VI, 11, 99, 105-107, 112, 120, 140.

Diagnosis: determination of the nature of a disease by the doctor, according to the symptoms discovered in the patient. VI, 30, 43, 62, 67, 70, 79, 86, 88, 132, 133, 146, 152, 154.

Diakinesis: the terminal stage of the prophase of meiosis, during which the chromosomes begin to move in order to place themselves on the equatorial plate. I, 117.

Diaphragm: a flat, elastic muscle, dome-shaped, in mammals, which separates the thoracic organs from the abdominal viscera. It is innervated by the phrenic nerve (tenth pair of cranial nerves); the diaphragm plays an important role in respiration. V, 15.

Diastole: a phase of the cardiac cycle during the course of which the ventricles fill with blood. The diastole follows the systole. V, 91, 92, 94; VII, 20.

Diatom: unicellular algae of which the protoplasm is enclosed in a siliceous carapace showing very fine patterns. The carapaces of fossil diatoms are to be found in geological strata in the form of very fine sand called tripoli. IV, 75; mi.

Dichotomy: in botany, a method of growth in plants resulting in bifurcated branches. III, 47, 48.

Dicotyledon: a class of flowering plants (Angiospermae) characterized by a symmetrical seed containing two cotyledons. These two parts of the seed are plainly visible in a haricot bean, for example. Dicotyledons include such diverse plants as the oak, nettle and daisy. III, 50.

Diencephalon: the between-brain, including the thalamus, the hypothalamus, and the base of the third ventricle. The diencephalon, linked by a series of connections to the rest of the brain, is a kind of crossroads where, in the thalamus, relays of all the sensory pathways (except the olfactory) meet, and in the hypothalamus, where the relays that ensure integrated action (nutrition and instinctive behaviour) meet. Here also the neurosecretory cells are localized, producing the post-pituitary hormones (vasopressin, oxytocin). VI, 98, 99, 103; mi.

Dietary deficiency: an absence or insufficiency of one or more elements essential for the maintenance and development of the organism. The deficiencies may be of chemical substances as well as vitamins and in the acute state are the cause of very serious diseases, such as kwashiorkor, scurvy, and beri-beri. VI, 99, 108, 109, 110, 119, 159.

Differential permeability: a fundamental property of cell membranes which shows itself in the selection of substances absorbed. I, 46, 47; IV, 26; V, 42, 43, 46.

Differentiation: transformation of an embryonic rudiment (cell or tissue) that has no fixed fate, into a differentiated structure that will play a definite role in the morphology and physiology of the organism, eg, an ectoderm cell may give rise either to a nerve cell or to an epithelial cell: a totipotent element has thus become unipotent. The differentiation of the various parts of an organism is dependent on a series of inductions. I, 95, 98, 138, 142, 152, 153, 154, 155; III, 76; VII, 29, 30.

Digital hippocratism: a deformation of the extremities of the fingers observed especially in chronic lung disorders; chronic tuberculosis, chronic bronchitis, lung cancer and dilatation of the lungs. It consists of a widening of the flesh of the last phalanx and a bending of the nails towards the palm, giving the fingers the appearance of a drumstick. VII, 122.

Dimorphism, sexual: the description applied when two sexes of a species present different morphological characters. It is variable according to species and is accentuated in insects. It is very marked in *Bonellia* (a worm), for example. I, 111-113; II, 49, 50;

Dioecious: a condition in which male and female flowers are borne on different plants, eg, a palm tree, or a hop. III, 17, 131.

Diphtheria: a contagious disease caused by the Klebs-Löffler bacillus; it is characterized by the production of false fibrinous membranes in the mucosa of the pharynx and the larynx, with general poisoning (paralysis, nephritis, and cardiovascular disturbances) caused by toxins secreted by the bacillus. IV, 130; VI, 51; VII, 82, 151.

Diphtheria bacillus: a Gram-positive bacterium shaped like a stick, causing diphtheria lesions by means of the toxins that it produces. This bacterium shows a special feature: it only becomes pathogenic under the action of a virus which starts the secretion of toxin. IV, 131.

Diploblastic: an animal in which all the organs are derived from two embryonic layers only, the ectoderm and the endoderm. Only multicellular animals of the most primitive kind are diploblastic (sponges, medusae and corals). I, 86, 88, 89; II, 17.

Diploid: an organism in which each cell contains two identical assortments of chromosomes, half coming from the father and half from the mother. In a sexually produced organism all cells are diploid, except for the mature germ-cells, which only contain one assortment of chromosomes and are said to be haploid. III, 16, 17, 57.

Diplopia: an anomaly of vision shown by the perception of two images of a single object. VI, 142.

Diplotene: a stage of meiosis (prophase) during which the chromosomes of a single pair divide into two, forming a tetrad (see Cell division). I, 117.

Disc hernia: see Slipped disc.

Displacement activities: a term employed in animal psychology to describe certain activities of a ritual or ceremonial character which occur during moments of tension (such as attack, defence, etc.) or in conflict. These activities do not generally have any relationship with the cause of tension. II, 78.

Diuresis: the quantity of urine secreted in a given time. In man, in normal physiological conditions, it is of the order of 1,200–1,500 cc per day but may reach 10 litres per day in internal disorders, such as diabetes insipidus. V, 23.

DNA: an abbreviation of deoxyribonucleic acid. See Nucleic acids.

Dominance: in animal psychology this expresses superiority of rank and the right of way of an individual of the group compared with the others. It is possible to determine, in an animal group, the order of dominance (or hierarchical order) following the number of defeats or victories of each individual during the course of fighting. II, 80, 81, 140, 141.

Dominant character: character controlled by a gene transmitted to all descendants of the filial generation, even when present in the heterozygote state, eg, in mice, the 'grey fur' character is dominant: all individuals of a generation produced from a cross between a grey mouse and a white mouse are grey. In the following generation 75 per cent of the mice are grey, 25 per cent are white; the grey fur character is dominant over the white. VI, 139.

Dormancy: in plants, a physiological condition that prevents germination. III, 62, 100-105.

Drepanocytosis: see Sickle-cell.

Drosera: carnivorous plants common in peat bogs. The leaves are furnished with long viscous hairs enabling the plant to capture small insects, which are digested by means of enzymes that split the proteins (proteases). III, 18; mi.

Drosophila melanogaster (or fruit fly): a small fly made famous through the work on heredity by the American school of T. H. Morgan. Its mutations have become classic examples in genetics. It reproduces rapidly, is easily fed and the giant chromosomes of its salivary glands are easy to observe. These qualities make *Drosophila* excellent laboratory material. I, 115, 117, 118, 120, 121, 124, 125, 126; II, 31, 32, 35, 50; V, 139; VI, 138; VII, 90.

Dupuytren's disease: a contraction of the aponeurosis which, thickened and infiltrated by nodules, causes a progressive flexion of the fingers, so that extension becomes impossible. It is observed especially in the fourth and fifth fingers. Aponeurectomy is the recommended surgical operation for this. VII, 104.

Dura mater: the external resistant membrane of the meninges. VII, 135, 136.

Dust: any kind of matter reduced to powder, either homogeneous or heterogeneous; in pathology this term is reserved for particles the dimensions of which lie between approximately a few hundred angström and 10 microns. The surface of these particles and their physical and chemical properties are important points to consider because they make up the harmful characteristics of these dusts. VI, 55, 58-63, 66.

Dysentery: an infectious disease characterized by abdominal pain, persistent diarrhoea and blood in the faeces. Dysentery may be of bacillary origin (Shiga's bacillus) or of parasitic origin (amoebic dysentery caused by *Entamoeba histolytica*). VI, 19, 41.

Dysgenesis: a tissue modification that shows itself by a deviation from normal histological appearance; in contradistinction to inflammatory and tumoural lesions. VII, 29.

Dyskeratosis: a pathological abnormality of the keratinization of the epidermis. This symptom is observed in Bowen's disease (q.v.). VII, 30.

Dyspnoea: difficulty in breathing. According to the type of dyspnoea, this may be tachypnoea, orthopnoea, bradypnoea (rhythm), inspiratory, or expiratory dyspnoea, etc. VII, 125.

E

Ear ossicles: small articulated bones situated in the middle ear between the tympanum and the fenestra ovalis, consisting of the malleus (hammer) inserted on the tympanum, the incus (anvil) and stapes (stirrup) which fits into the fenestra ovalis. V, 112, 114-117.

Ecdysone: hormone inducing moulting in insects, secreted by the prothoracic gland. It controls the complex processes of division of the epidermic cells of the insect and the renewal of the external integument. II, 45.

Echinoderm: a phylum of marine animals with a radial symmetry, in which the integument is nearly always calcareous and is sometimes covered with articulated spines. The echinoderms are remarkable for their metamorphosis, during which, on a bilateral symmetry, a pentaradial symmetry is substituted. The commonest types are the sea urchins and starfish. II, 17, 18.

E.C.H.O. (Enteric cytopathogen human orphan): a group of viruses that are parasites in the human intestine, but up to now without having been found to cause any well-defined disease. VIII, 69.

Ecology: the study of living beings in terms of the natural environment where they develop and multiply. An outcome of evolutionary theories (natural selection and competition for survival), ecology is one of the essential aspects under which a knowledge of the problems of life must be envisaged. The natural environment is defined by a certain number of physical and chemical characteristics: nature of the soil, topography, climatic conditions (temperature, humidity, sunshine, and air turbulence). These physical and chemical characteristics *in toto* determine the formation of certain plant and animal associations. Following the interdependence of these species and the reciprocal action that they exercise on each other (competition for survival), these associations are found in a state of biological equilibrium that may be broken by the modification of only one of these determining physical and chemical factors, or by the disappearance of only one of the species of the association, or by the introduction of a species not belonging to the previously established association. In considering the interdependence of all these living beings, ecology may be looked at from a general angle, that is to say, as the totality of the relations that unite all forms of life, both plant and animal. It is possible also to look at it from the angle of a restricted environment (biotope), of a micro-climate: for example, a pond with its vegetation and all the aquatic and land species that live there; a sea-shore, with associations of algae and macroscopic marine animals and microscopic ones that are adapted to a tidal system; a lump of earth on which, living between the seeds, in biological equilibrium, are bacteria, microscopic fungi, worms (nematodes) and primitive insects. II, 15, 17, 53, 54, 154; III, 113-117; IV, 54, 155.

Ectoderm: the external layer of the embryo brought into position at the moment of gastrulation (synonym: epiblast). I, 127, 133, 134, 136; VII, 29.

Ectoparasite: a parasite living on the surface of the body of its host, but not fixed to it. Such are fleas, lice and ticks; the opposite of endoparasite (q.v.). II, 105-107.

Ectophyte: a plant parasite that lives outside its host, eg, mistletoe. III, 68.

Eczema: a cutaneous lesion, characterized first by redness of the skin, then by the formation of small vesicles full of a serous liquid, which break, forming yellowish crusts. Eruption occurs generally in irregularly shaped areas which itch and extend in successive waves. Eczema is frequently linked to states of hypersensitivity. VI, 66, 70.

Edaphic: related to the soil (eg, botanists speak of 'edaphic factors' as opposed to 'climatic factors'). III, 121, 122.

Effector organs: organs capable of exercising an action on the external world, eg, the hand; the opposite of receptors. II, 66.

Egg: an immobile germ-cell, or gamete, produced by female organisms as the result of oogenesis, containing the haploid number of chromosomes. See Gamete. I, 90, 127, 128, 129, 130, 131.

Egg, fertilized (or zygote): a cell resulting from the fertilization of a female gamete (or egg) by a male gamete (or sperm). It contains the diploid number of chromosomes and all the necessary hereditary potentialities for the formation of a new organism. According to whether it has reserves of yolk, an egg is said to be telolecithal, lecithal or oligolecithal. I, 90, 127, 128, 129, 130, 131, 133, 135.

Electrocardiography or ECG: the study of the electric currents liberated by the contraction of the heart muscle. These currents are detected by electrodes placed on the hands and round the ankles and relayed to a special apparatus, the electrocardiogram, with which one can follow in detail the functioning of the heart muscle. The curve recorded is an electrocardiogram. VI, 33, 80, 84, 86; VII, 23, 128.

Electrocorticography: electroencephalography practised by placing electrodes in contact with the cerebral cortex itself, after trepanation and piercing of the dura mater. It is used to ascertain, before excision, the location of a focus of epilepsy in the cerebral cortex. V, 74; VII, 23, 128, 138.

Electroencephalogram (or EEG): a tracing obtained by registering the electric activity of brain cells. The elements that make up an electroencephalogram may be classified into four groups: alpha waves (8 to 13 cycles per second), taken from the posterior region of the brain; beta waves (15 to 30 cycles per second) taken from the anterior part of the brain; theta waves, from the temporal lobes; and delta waves, characteristic of sleep. The amplitude and frequency of waves vary according to the state of the subject (wakefulness, sleep, coma or epilepsy); the modifications of the electroencephalographic tracing enable the diagnosis of certain diseases (epilepsy) or the localization of tumours or brain lesions to be made. V, 61, 71, 72, 74, 76, 79, 81, 83; VII, 21, 54, 125, 137, 138.

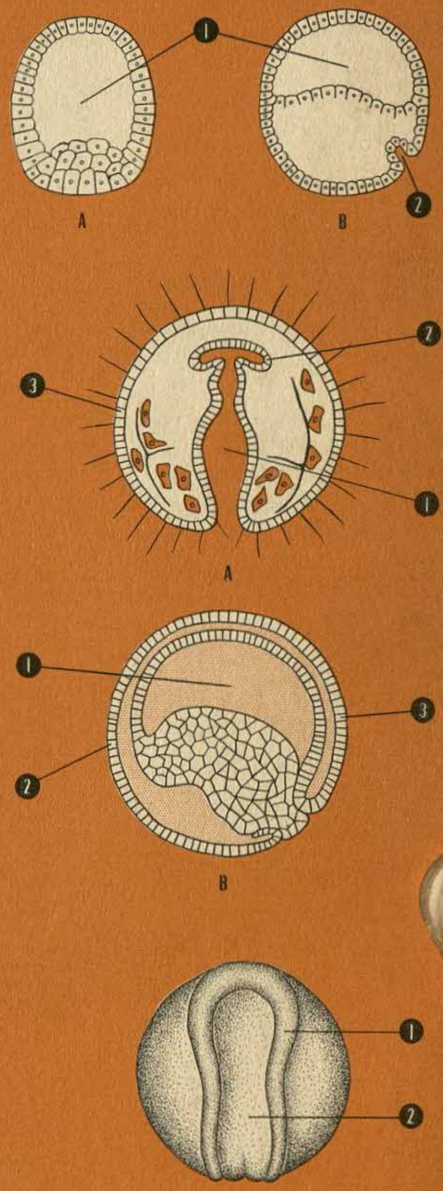
Electroencephalography: recording of the electrical activity of the brain by means of electrodes fixed on the scalp. The electric currents produced by the neurones are amplified, then recorded by a cathode ray oscillograph provided with a writing stylus. The tracing thus obtained is an electroencephalogram. V, 62, 71, 72, 74, 76, 79, 81, 83.

Electromyography: detection and recording by means of electrodes, of the electrical activity of muscle fibres. V, 142, 143; VII, 23.

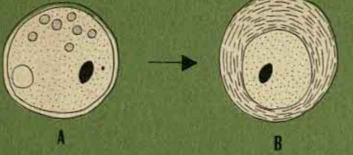
Electron microscope: an apparatus analogous to the microscope, in which light rays are replaced by a stream of electrons. These electrons, emitted in a vacuum tube by a cathode, go through the object and are deflected by condensers to form a very much enlarged image on a fluorescent screen. I, 29-32; IV, 106; VI, 35, 135; VII, 29, 35.

Electrophoresis: a method of separating some of the constituents of a colloidal solution by subjecting them to the action of an electric field. The particles that are charged positively or negatively each migrate towards the opposite poles of the field at different speeds according to the charge and the dimension of the particle. Electrophoresis is used to separate the different proteins in blood serum. I, 153; IV, 106, 110; VI, 33; VII, 28, 53.

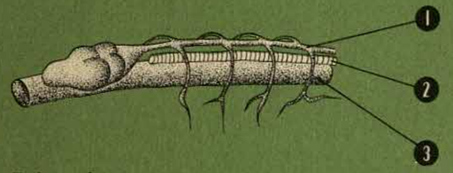
Electrophorus: a tropical eel, provided with an electric organ that is the result of modification of certain muscle fibres into 'electroplates'. In these special cells, like accumulators placed in series, synchronous electric discharge possesses a considerable difference of potential, which may reach 600 volts. II, 69.



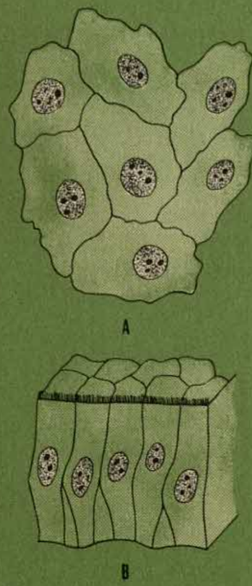
Embryo
Blastula stage: A. Sea urchin. B. Frog. 1. Blastocoel. 2. Blastopore. Archenteron. A. Sea urchin. B. Frog. 1. Archenteron. 2. Endoderm. 3. Ectoderm. Neurula (frog). 1. Neural fold. 2. Neural plate.



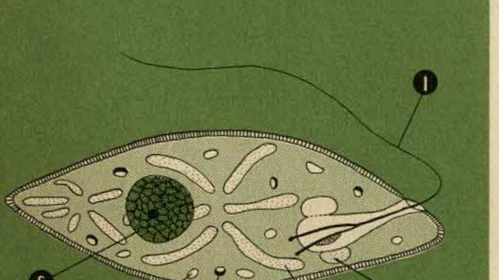
Encystment (ciliated infusoria)
A. Intermediate stage. B. Cyst.



Epineurian
1. Dorsal nervous system. 2. Notochord. 3. Digestive tract.



Epithelium
A. Epithelium (squamous). B. Columnar epithelium.



Euglena
1. Flagella. 2. Stigma. 3. Chloroplast. 4. Dictyosome. 5. Vacuole. 6. Nucleus.

Electrophysiology: a branch of physiology the aim of which is to study the electrical phenomena that appear in the functioning of different cells, tissues or organs. II, 72.

Electroretinography: graphic recording of electric currents liberated by the retina. VI, 144; VII, 23.

Embolism: an accident of circulation due to the obstruction of a blood vessel by a clot, an air bubble, or a fragment of tumour. Transported by the current of the blood, circulation, where it stops it forms a plug, owing to the narrowness of the vessel, and prevents the blood from circulating. V, 150, 151; VII, 130.

Embolus: a foreign body circulating in the blood, not only a thrombus, but also air, fat, clumps of bacteria, and malignant cells. The embolus causes embolism, which is the sudden obstruction of a blood vessel or a lymph vessel. VII, 130.

Embryo: an organism in the first stages of development after fertilization of the female gamete by the male gamete. The progressive organization of the embryo, or embryogenesis, begins in the same way in both animals and plants: the egg is segmented and forms a small clump, or morula, of embryonic cells, the blastomeres. After this stage, the embryogenesis of animals is very different from that of plants. After the first divisions of segmentation, the animal embryo, in which an animal pole, a vegetative pole, and a plane of bilateral symmetry are already determined, takes the shape of a small sphere that is either solid or hollow, called the blastula. The cavity of the blastula is the blastocoel. In sponges and some Coelenterata (hydras, anemones and medusae) and in certain flat worms (planarian worms), embryogenesis stops after infiltration of mobile cells derived from the vegetative pole, the cells of the mesenchyme. In the case of other metazoa, embryogenesis continues with gastrulation: at this stage there occurs an invagination of the blastula that carries the endoderm to the inside. This is the gastrula stage, with two embryonic layers, one external (the ectoderm), the other internal (the endoderm). To these, in animals above the Coelenterata, is added a third layer, the mesoderm, introduced between the ectoderm and the endoderm. The mesoderm is itself constituted of two layers of cells (the somatopleur and the splanchnopleur) between which a series of cavities hollows out, forming the coelom. In the following phase, that of neurulation, the neural plate differentiates, under the influence of the organizer, which acts as an integrating centre for future organization. The layers are brought into place and their fate is permanently fixed: each of them, by a series of successive inductions, will ultimately give rise to a particular system of organs. In plants, embryogenesis is much more simple; after the divisions of segmentation, it goes no further than the stage which is equivalent to that of the morula, the small mass of blastomeres. However, here also there exists from fertilization onwards an axis of symmetry that will govern the subsequent growth of the embryo. At the two poles of this axis (the extremity of the root and the extremity of the stem) the meristems will persist, these being embryonic masses of cells that preserve all the potentialities of the embryo. The growth of plants is thus a kind of continuous embryogenesis. The embryo of a plant together with the albumen, constitutes the essential part of the seed. An embryo is composed of a shoot, a growing point, one or two cotyledons, and a root-tip. I, 18, 19, 24, 25, 80, 81, 83, 153, 154; III, 13, 44, 64, 74.

Embryogenesis: the stages of development following fertilization that lead to the localization of the rudiments of the future parts of an organism. I, 133, 134; III, 61.

Embryon sac: a sub-epidermic cell of the nucleus, situated in the axis of the latter, which appears during the course of development of the ovule. III, 66.

Embryopathy: diseases of the embryo, malformations due to toxic or infectious factors that affect the foetus during embryonic life. VI, 143.

Emphysema: excessive permanent dilatation of the lung alveoli and the bronchioles in cases in which they have lost their elasticity. Emphysema leads, more or less quickly to respiratory insufficiency. VI, 14, 54, 62; VII, 22.

Encephalitis lethargica: an infectious disease caused by a virus similar to that of poliomyelitis. It is shown by fever, sleepiness, and a paralysis due to certain cranial nerves being affected, and sometimes by psychological disturbances. The vectors of encephalitis are ticks and mosquitoes. VI, 19.

Encephalomyelitis: in a general way, inflammation of the brain and spinal cord, characterized by headaches, stiff neck and visual, psychological and motor disturbances. Some types of encephalomyelitis are caused by viruses. VI, 51.

Encystment: transformation from a normal form to a resistant form called cyst. Encystment is produced when the organism is in difficult circumstances (heat, dryness, and an alteration of pH). Under these conditions the organism gets rid of its water and surrounds itself with a resistant shell that is impermeable, from which it frees itself when the conditions of the external environment are more propitious to its development. The cyst is a means of dissemination in certain protozoa and parasitic worms (liver fluke). III, 57; mi.

Endemic: a general term designating any infectious disease that occurs permanently in any particular locality; eg, yellow fever is endemic in Central America, and cholera in India. VI, 27, 42, 43, 46, 110.

Endergonic reactions: all synthesis requires energy for its realization. The living being must have at its disposal an external energy (exergonic reactions) in addition to its internal energy (endergonic reactions). IV, 64, 65.

Endocarditis: inflammation of the wall that lines the inside of the cavities of the heart; it may or may not be of infectious origin. It is often associated with acute rheumatic fever. VI, 133.

Endocrine: in animal physiology, a gland inside the body that secretes (in blood or lymph) a substance called a hormone that acts at a distance and in a specific way on an organ or part of the organism. I, 89; VI, 90, 96, 97, 99, 102, 103, 106, 119, 120.

Endoderm: the internal layer of the embryo which later is differentiated into the digestive tract. I, 127, 129, 133, 134.

Endometrium: among female mammals, the mucosa that lines the inside of the uterus. V, 58.

Endomitosis: see Pairing, chromosome.

Endoparasite: a plant or animal parasite that lives inside the organism (digestive tract and places nearby, circulatory and muscle tissue). Sometimes this term is applied to parasites that live inside the cells, such as viruses. II, 105, 107, 108.

Endophyte: a plant parasite that lives inside its host. III, 68.

Endoplasmic reticulum: see Ergastoplasm.

Endoscopy: examination of the cavities (oesophagus, bronchi and rectum) and hollow organs with a narrow opening (bladder) by means of a tubular optical instrument analogous to a periscope and provided with a source of light. VI, 61.

Endothermic: see Endergonic reactions.

Endotoxin (or antigen O): a toxic substance made by a pathogenic bacterium which cannot be freed into the ambient environment, except by a dead organism or during the course of autolysis; a term contrasted with exotoxins. These, after their formation in the bacterium, are excreted into the environment by living microbes. Only Gram-negative bacteria secrete these endotoxins, which are very complex and have a high molecular weight with a similar composition of simple glucosides, simple proteins and phosphorylated lipids. The lipids appear to constitute the toxic element; according to the species of bacteria considered, the proportion of different constituents is variable, which gives endotoxins a certain specificity. Their physiological action, however, on organisms is similar: the symptoms of poisoning by endotoxins are always the same (diffuse haemorrhage in organs, very high fever, diminution of the number of white cells, and hyperglycaemia). Endotoxins behave like antigens in that they cause the appearance of specific antibodies, but they are weak antigens, a very strong dose being required before physiological disturbances appear (2 mg in a guinea-pig). The mode of action of endotoxins has not yet been elucidated. It appears that under certain conditions they favour the appearance of hypersensitivity and a state of shock, which is reminiscent of the general adaptation syndrome, the 'stress' syndrome of Hans Selye. In practice, since the organism provides specific anti-endotoxin antibodies, it is used against these bacterial poisons by means of preventive vaccination, particularly in the case of typhoid, A and B paratyphoid, and typhus. IV, 27-29, 79, 81-84, 133.

End-plate potential: a local phenomenon of electric depolarization occurring in the motor end-plate and the muscle fibre, following the arrival of nerve impulses in the termination of the motor nerve fibre and preceding the action potential of the muscle fibre. V, 66, 67.

Energid: a cell with its nucleus and dependent cytoplasm. A unicellular organism is said to be a polyenergid when it encloses a number of energids in the same cell membrane; that is to say, when it has more than one nucleus, as in certain Foraminifera. I, 87.

Enterobacterium (or enteroccus): a diplococcus (see Coccus) normally present in the mouth and the digestive tract of man. The enterobacterium can, under certain conditions, become pathogenic and cause enteritis, pleurisy or meningitis. IV, 75, 135.

Enterovirus: a group of viruses made up of RNA that fix themselves on cells of the intestinal mucosa. The main enteroviruses are those of poliomyelitis, coxsackie viruses, and E.C.H.O. viruses. Sometimes, under circumstances imperfectly understood, these viruses become neurovirulent and attack the nervous system, causing serious paralysis. VI, 38.

Entomophagy: feeding on insects. Certain insects may themselves be entomophagous; they are sometimes used in biological work when their prey is a harmful insect. II, 154, 156.

Entomophily: the pollination by insects of certain flowers: the honey-making insects visit flowers, carrying pollen which they leave on others. II, 132; III, 59.

Entophlyctis: a primitive unicellular fungus possessing two remarkable characteristics: it is aquatic; and under certain conditions it may transform itself into a kind of giant amoeba with pseudopods that are very long and very branched; it then attacks other plants, enveloping them in its pseudopods, and digests them. III, 69, 60.

Enzymes: chemical substances, very small quantities of which will considerably accelerate the speed of metabolic processes within the living cell; an enzyme is thus a biological catalyzer, generally formed of two parts: one, a protein, the apoenzyme or prosthetic group, and the other of varied nature, the coenzyme, which may be either a metallic ion or a vitamin (B, PP, C, etc.), or an organic substance that is more complex. The same coenzyme may attach itself to different prosthetic groups, but in general, the complete enzyme (apoenzyme plus coenzyme) is specific for a given reaction. The enzymes that catalyze any given reaction are the same everywhere, whether in the case of algae, ferns, insects or mammals; these substances have therefore been classified, according to the kind of activity that they exercise, into a few big families. There are, for example, the neucleases that degrade nucleic acids, the transferases that transport a chemical radicle from one molecule to another, the dehydrogenases that take hydrogen ions from organic substances, the proteases that degrade proteins into amino acids, etc. A particularly important group of enzymes are the respiratory ones, which function in phenomena of cell respiration (Krebs' cycle and cytochromes). I, 39-42; IV, 26, 47, 48, 60, 62, 65, 91, 106, 113; V, 26, 50, 51, 127, 136; VI, 11, 48, 53, 62, 82, 91, 120; VII, 28, 84, 85, 90.

Eosinophilia: a property possessed by the cytoplasm of certain cells to fix acid stains, in particular, eosin. Such cells are said to be eosinophil or acidophil (eg, esinophil polymorphonuclear cells, eosinophil cells of the anterior pituitary). IV, 115; V, 28; VII, 31, 35, 101.

Ephedrine: an alkaloid derived from *Ephedra*, used in the hydrochloride form and possessing numerous properties: ephedrine relaxes smooth muscle of the bronchial wall, excites the respiratory centre of the medulla, and exercises a vaso-constrictive action on peripheral vessels; it also reinforces the tone of the heart muscle. Synthetic ephedrine has now replaced the natural product. VII, 53.

Epidemic: any infectious disease that attacks a large number of individuals at the same time and in the same region, eg, in an influenza or smallpox epidemic. VI, 14, 29, 31, 32, 33, 35, 37, 46, 66; VII, 78.

Epididymis: a structure situated between the body of the testis and the vas deferens. The epididymis is at the upper end of the testis. VI, 102.

Epilepsy: a disease characterized by the repetition of sudden crises, usually showing three phases: (1) the tonic phase, following immediately on the collapse of the patient: the muscles are stiff, the upper limbs are flexed, the lower limbs are extended; this phase lasts only a few seconds; (2) the clonic phase; short periods of relaxation diminish the muscular hypertonia, resulting in sharp shudders; this lasts some dozens of seconds and often leads to tongue-biting; (3) the comatose phase with muscle relaxation: this may last a few minutes or a few hours, with loss of urine. The crises are usually followed by sleep. VII, 21, 135, 138.

Epineurian: an animal in which the nervous system is placed dorsally above the digestive tract. All vertebrates are epineurians. The opposite is hyponadurian. II, 17, 18; mi.

Epiphytes: plants which, without being parasites, grow on other plants, requiring support from their host but not nourishment. Epiphytes are found especially in ferns, certain mosses (Spanish mosses) and most orchids. II, 122, 123.

Epithelium: a tissue, usually thin, formed of cells that are juxtaposed and stratified in a number of layers, covering the body or the inside of hollow organs (such as gastric or intestinal epithelium). I, 60, 61, 62, 65, 79, 145, 150; VII, 30; mi.

Epizootic: any infectious disease that attacks a large number of animals at the same time and in the same locality. VI, 19.

Equatorial plate: the median plane of the spindle on which are assembled the chromosomes during metaphase in the mitosis of a cell. I, 62, 63.

Ergastoplasm: structures in the cytoplasm (q.v.) of a cell. Ergastoplasm, often called 'endoplasmic reticulum', is formed by double layers along which are grouped microsomes; it plays an important part in the synthesis of protein. I, 53, 58, 61.

Ergodynamography: graphic recording of muscle contraction. V, 142, 143.

Erysan: a nitrogen mustard (B-naphtylamine) used in the treatment of malignant disorders. VII, 90.

Erythroblast: a precursor of a red cell, normally present in bone marrow. IV, 103; VI, 82; VII, 31.

Erythroblastaemia: the presence in the blood of nucleated red cells arising from a defect in the differentiation of red cells (normal red cells do not contain a nucleus). VII, 34.

Erythrocyte: see Red blood cell.

Erythrolabe: a pigment in the cone cells of the retina that selectively absorbs red luminous radiation (hypothesis of W. A. H. Rushton). V, 106, 110.

Erythromycin: an antibiotic widely used in common pus-forming infections, particularly by staphylococcus. See Macrolides. VII, 87.

Eschars: ulcerations of the skin and subdermal tissue of a greater or lesser extent, covered by a fairly thick blackish crust formed by necrotic tissue. They appear after a prolonged stay in bed. VII, 145.

Escherichia coli: colibacillus. A bacterium 3 microns in length, the colibacillus is part of the usual microbial flora of the intestine in man; it may, under certain pathological conditions, cause urinary infection (colibacillosis) and even general infection. It is easy to culture, and has been widely used in the last few years in studies involving experimental genetics and the construction of chromosome maps. I, 53, 119, 123; IV, 10, 15, 20, 25, 33, 34, 35, 38, 41, 44, 121.

Ethioniamide: a product of synthesis, an important anti-tuberculous substance, possessing bacteriostatic and bactericidal properties, coming next after isoniazid, in the treatment of tuberculosis. VII, 41.

Ethology: the biological study of the behaviour of animals in their environment, in order to understand the impulses that actuate them. II, 54; VI, 155, 156.

Eucaryote: an organism in which cell nuclei are completely separated from the cytoplasm by a membrane, as distinct from protokaryotes, such as bacteria or cyanophycae (blue algae) where the nuclei are incomplete or imperfect. III, 46, 56, 57.

Eudorina: a type of colonial flagellate. In *Eudorina* thirty-two cells are grouped in a defined order. In asexual reproduction a cell may give rise to a daughter colony; sexual reproduction is between male and female colonies. III, 58.

Euglena: a flagellate unicellular organism in which the cytoplasm contains chloroplasts. *Euglena* possesses a sensory organ, the stigma, that is sensitive to light and enables it to direct itself. This elementary photoreceptor organ, linked to the base of the flagellum and formed by fifty small rods containing an orange pigment related to rhodopsin, may be considered, from the evolutionary point of view, as the first rudiment of the eye. The fact that *Euglena* possesses both a stigma and chloroplasts gives this organism a special place athwart both the plant kingdom and the animal kingdom. I, 15, 17; mi.

Eupnoea: normal respiration, the opposite of hypernoea (too rapid respiration). In man, the rhythm of respiration is 20 per minute; its duration (3 seconds) is unequally divided between expiration and inspiration: the exp./insp. ratio is 10/15.

Evocator: a chemical substance that arouses the latent potentialities of part of an embryo; a morphogenic stimulus. Also, in animal psychology, a stimulus-signal (q.v.). I, 136-142; IV, 75-79.

Evolution: the progressive transformation of species by a series of successive modifications that has led them towards more efficient adaptation. The general line of evolution has thus gone, in the animal world, from the Protozoa to man; in the plant world, from Protophytes to Angiosperms, with numerous intermediate stages that have had fruitful evolutionary paths (such as those leading from the insectivores to primates and to the human species), as well as paths that are blind alleys or the dead-ends, such as the ascidia, lateral branch of the Protochordates which have never become vertebrates. Through the study of evolution a classification of living beings has been established: two continuous series, the one belonging to the animal world, the other to the plant world, in which the most highly evolved organisms are derived from those that have more archaic characters. The phenomenon of evolution must have started with the beginning of life on this planet and there is a chronological order in the appearance of living beings; therefore, in order to find the missing links in one series or another, reference must be made to palaeontology, the study of fossils. Some species that appeared some millions of years ago and have remained unchanged (living fossils) are of great interest in the study of evolution. Theories based on natural selection, mutations and the isolation of species have been brought together in what has been called the synthetic theory to explain the mechanism of evolution. As the basis of an evolutionary modification there must have been mutations; that is to say, the transformation of genes, followed by recombinations of these genes in different permutations through Mendelian genetics. Natural selection will only allow those genotypes to survive that are best able to live; by geographical isolation, the new population thus created eventually becomes a new species. This theory is founded on the fact that no change occurring in an individual can be transmitted in a hereditary manner if it does not affect the vehicles that carry heredity, ie, the genes. One must also take into account the existence of a cytoplasmic heredity, with less rigid laws than those of chromosomic heredity as defined in modern genetics. I, 18, 19, 21-25; II, 16, 24, 25, 31-37, 43, 91; IV, 31-37.

Exeresis: see Ablation.

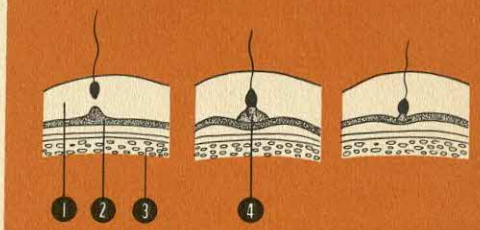
Exocrine: a gland of which the products are excreted from the body; eg, salivary glands, sweat glands and exocrine pancreas. VI, 96.

Exophthalmia: a protrusion of the globe of the eye from its orbit, sometimes caused by the presence of a tumour at the back of the eye, more often, by a hyperfunctioning of the thyroid gland (Basedow's disease), (q.v.).

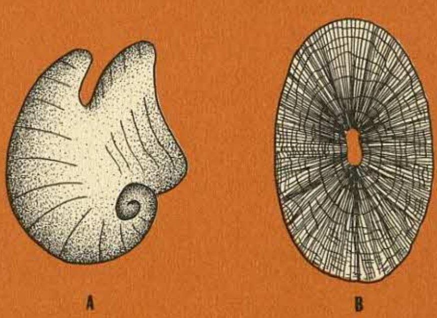
Exophthalmic goitre: see Basedow's disease.

Exothermic (exergonic) reactions: reactions that release heat. II, 64.

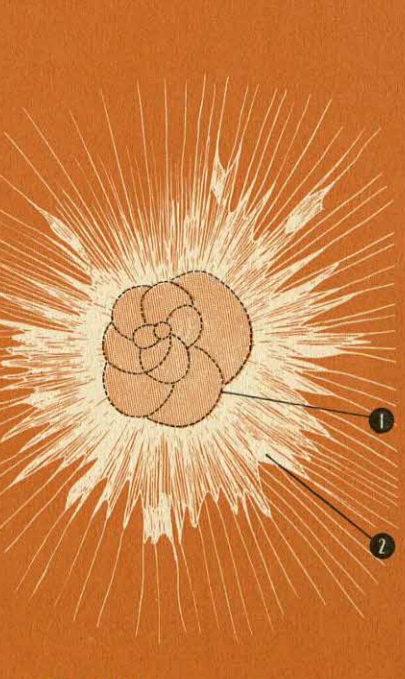
Exotoxin: a substance with a pronounced toxicity produced by some pathogenic bacteria which, as soon as it is formed in the cytoplasm of the living pathogenic germ, filters through the membrane and spreads into the surrounding medium. Only certain Gram-positive bacteria secrete exotoxins; for some of them, these toxins are essential for normal growth (diphtheria bacillus). Of very diverse composition, the exotoxins produced by different bacteria are always proteins and because of this possess very strong antigenic potency. The botulinic and tetanic toxins, for example, are lethal to man in doses of a thousandth of a milligramme; but they only act if they are directly in contact with blood inside the body; absorbed by the digestive tract and subjected to the normal disintegration undergone by all food substances, they are ineffective. In the infected organism each exotoxin has a specific action: some only act on the skin and the mucosa (necrosing action of scarlet fever toxin and diphtheria toxin); others destroy blood cells (haemolysins and leucocidine); others, including the most dangerous, attack the nervous system (neurotoxins), botulin toxin paralyzing the motor-end-plates, the points of junction of the motor nerves and the muscles, tetanus toxin exciting the inhibitor synapses of the central nervous system, leading to spasmodic contraction. With exotoxins, the contrary of endotoxins, it is possible to dissociate antigenic potency from the toxic potency: there are then obtained toxoids which, introduced in an organism, produce the formation of persisting antibodies: diphtheria and tetanus



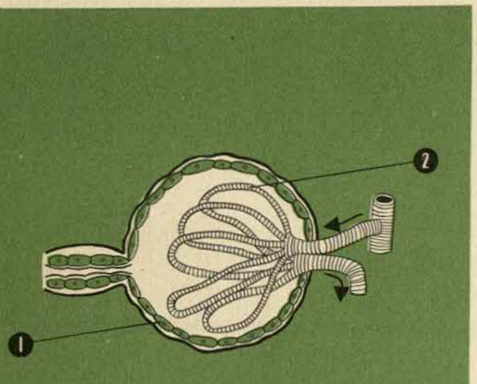
Fertilization (starfish: Asterias)
1. Mucous membrane. 2. Fertilization membrane. 3. Cytoplasmic granules. 4. Core of attraction.



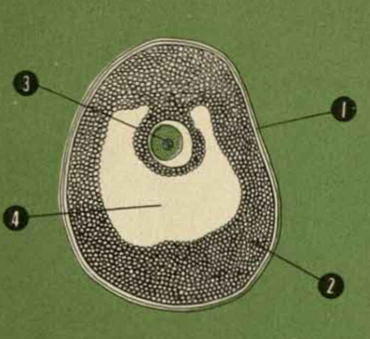
Fissurella
A. Immature stage. B. Adult stage.



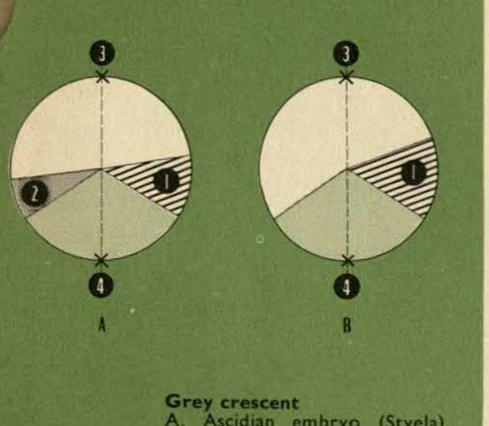
Foraminifera
1. Shell. 2. Pseudopodia.



Glomerulus
1. Bowmann's capsule. 2. Glomerular capillaries.



Graafian follicle
1. Membrane. 2. Theca interna vessels. 3. Ovum. 4. Liquor folliculi.



Grey crescent
A. Ascidian embryo (Styela). B. Frog embryo. 1. Grey crescent. 2. Yellow crescent. 3. Animal pole. 4. Vegetal pole.

toxoids used in preventive vaccination are two of the most efficacious vaccines in modern prophylaxis. III, 69; IV, 27, 79, 81, 83; VII, 81, 82.

Experimental psychology: an experimental method applied to the animal to discover the psychological mechanisms by which it operates; it includes the interpretation of these facts in man, taking into account his unique nature. VI, 153-157.

Exudate: in pathology, aqueous liquid that includes mainly fibrin and white cells which, under the effect of an inflammatory reaction, filters through the walls of the blood vessels into neighbouring tissue. VI, 144.

Exteroceptor: organs that receive excitations from outside (eg, the sense organs). II, 65.

Extreme environment: a natural environment where conditions are very different from those of normal human life (20° C, 760 mm of atmospheric pressure, oxygen, light, etc.). Examples of extreme environments are the great marine abysses, high altitudes, and caves. II, 53-57.

Eyespots: see Ocelli, ocular.

F

Fallopian tube: in the female genital system of mammals, a tube connecting the ovary to the uterus, through which unfertilized eggs pass after ovulation. I, 144, 145, 150.

Fallot syndrome: see Tetralogy of Fallot.

Fats: see Lipids.

Fauna, abyssal: characteristic fauna of the sea depths (below 6,000 metres). II, 57.

Feed-back: a term borrowed from cybernetics to describe regulatory mechanisms in which excess is automatically checked or insufficiency made good. This is how, in the human body, temperature, osmotic pressure, pH and concentrations of substances in the blood are kept constant. For instance, a fall in the concentration of adenosine triphosphate creates the conditions needed for its synthesis. There is cybernetic control of ovulation in mammals by the alternate and reciprocal stimulating and inhibitory secretions of the pituitary and the ovaries. I, 159; V, 21 (see Correlation).

Fermentation: transformation of organic substances by the action of enzymes produced by micro-organisms, eg, transformation of milk lactose into lactic acid by lactic bacteria; transformation of alcohol into acetic acid by acetic bacteria. III, 29, 30; IV, 144; VII, 84, 86.

Ferns: a class of plants characterized by their alternating cycle of generations. This cycle is distinguished from that of mosses by the greater importance of the sporophyte generation. III, 16, 50, 57, 58.

Fertilization: in every being that reproduces by sexual reproduction, the fusion of a male gamete with a female. The method of fertilization varies according to species. II, 51, 52; III, 66, 67; mi.

Feulgen's reaction: a method of specific staining of deoxyribonucleic acid (DNA). I, 50, 60.

Fibrin: an insoluble substance resulting from the action of an enzyme (thrombin) on soluble fibrinogen normally contained in the platelets and in blood plasma. The formation of fibrin represents the final and essential phase of coagulation. V, 34, 35, 37, 52; VII, 28.

Fibrinogen: a fibrillary protein of blood plasma transformed into insoluble fibrin following blood coagulation. I, 153; V, 35, 36, 37; VII, 53.

Fibrinolysis: the destruction of fibrin in blood clots, leading to their dissolution. Fibrinolysis only occurs in pathological cases (shocks and burns). V, 35.

Fibroblasts: cells of adult or embryonic tissue, capable by filiform extensions of protoplasm, of forming the solid elastic and resistant fibres that constitute the basis of connective tissue. In tissue culture, it means the way in which certain cultured cells *in vitro* can change and lose their structure and specialized functions, while retaining their ability to multiply. I, 58, 62, 70-72; II, 59.

Fibromyoma (or uterine fibroma): a benign tumour formed by smooth muscle tissue and the connective fibres of the uterus. VII, 104, 110.

Fibroplasia, retrolental: an ocular affection occurring in premature infants a few months after birth. It is characterized by the appearance of a fibrous opaque nacreous membrane behind the lens. VI, 143, 145.

Filariasis, Bancroftian: a parasitic disease caused by parasitic worms of the blood vessels and lymphatic vessels. Contamination is made by a mosquito that inoculates the embryo of the filaria at the moment of biting. This disease shows itself by various disturbances, eg, febrile attacks with neuralgia, haematuria, adenopathy, oedema of the lower limbs (elephantiasis). VII, 75, 76.

Fimbriae: in Protozoa, filamentous outgrowths, distinct from the cilia or the flagella; shorter, finer, more numerous and more rigid, the fimbriae seem to have no connection with the motility of the cell, but give them certain adhesive properties. IV, 47, 48.

Fish: aquatic vertebrates of which the non-horny skin is covered by scales and the limbs are used for swimming. They breathe by means of gills and their adult kidneys are mesonephric. Their brain is small and they possess special sensory organs localized in lateral lines. They are oviparous and heterothermic or poikilothermic. II, 19, 20, 25; IV, 17, 20.

Fissure: a more or less deep fold in the cerebral cortex limiting a convolution. The main fissures are those of Rolando, Sylvius, calcarine fissure, and the interhemispherical fissure. V, 60, 69, 73, 119.

Fissurella: a gastropod formed by a single conical shell provided with an opening at the top. *Fissurella* is a living fossil. II, 27; mi.

Flagellates: a class of unicellular animals that are very highly developed, possessing one or more flagella, ie, filamentous appendices that are mobile and allow it to move. The commonest type of flagellate is *Euglena*. This group includes types that are parasitic in man, such as the trypanosomes, the vectors of sleeping sickness, or *Trichomonas*. I, 85; III, 56, 57; IV, 47, 48.

Flocculation: coagulation in the form of floccules that deposit themselves at the bottom of the container from an unstable serum; they are produced by disequilibrium of the serum's constituents in the presence of certain reagents. VII, 28.

Fluid, or humoral environment (sometimes called internal environment): all the extracellular fluids in an organism. V, 29; VII, 50.

Folic acid: a vitamin of the B group, also called vitamin Bc, a deficiency of which leads to hyperchromic anaemia in various animals. It is active in man in the form of folinic acid, a deficiency of which, together with a deficiency of Vitamin B_{12}, is partly responsible for pernicious anaemia. II, 66.

Folioles: constituent parts of composite leaves or palmates. Folioles are inserted independently on to the petiole of the leaf (clover, chestnut, and acacia). III, 12.

Folliculin: a hormone secreted by the ovaries that leads to the development of female sexual character, and in each menstrual cycle starts the proliferation of the uterine mucosa before ovulation. V, 54, 57; VII, 35.

Folliculo-stimulin: a hormone secreted by the anterior lobe of the pituitary, which in women stimulates the maturation of the ovarian follicle. V, 58, 59.

Fomes: a basidiomycete fungus that develops on tree trunks. III, 58.

Foodstuffs: from the physiological point of view foods are divided into three categories: (1) energy foods, which supply the organisms with the calories required to meet energy output; (2) foods of a chemical nature, the presence of which is essential in the organism to carry out certain kinds of chemical synthesis (vitamins, trace elements and essential amino acids); (3) roughage, which cannot be digested but which plays an important mechanical role and favours peristaltic movement. VII, 109.

Foramen ovale: in the embryo, the single primitive auricle divides into two, the right and the left, by means of a muscular wall, the septum. The foramen ovale is an opening that persists abnormally after this separation and connects the two circulations; normally it disappears before birth. VII, 120, 121.

Foraminifera: small unicellular animals each enclosed in a flat calcareous capsule that is often perforated by numerous orifices. I, 86; II, 56, 57; mi.

Fossils: plant or animal remains of past geological eras which have been preserved by a particular process. There are several types of fossilization: it may be caused either by the total substitution of living matter by mineral salts (silicates or carbonates), or by a catalytic process still unexplained, both resulting in the enclosure of the organism in a stone shape; the latter results in the well-known forms of fish and ferns. Fossils also include small invertebrate organisms enclosed in amber, and by extension, the frozen remains (mammoths) or the 'clumps' of large animals (rhinoceroses) found in oil-bearing areas and dating from the beginning of the quaternary era. II, 22-29; III, 49, 53, 55.

Fovea: a yellow spot situated in the centre of the retina, containing the highest density of daylight photo-sensitive cells, the cones. The fovea does not contain rods. It is the essential instrument of visual perception in man and in all species which have a similar eye structure. V, 103, 106.

Free-martin: intersexual heifers born to a cow which has been delivered of twins of different sex; this phenomenon is explained by the fact that following the establishment of vascular communication between the two foetuses, the hormones of the male foetus inhibit the normal development of ovaries in the female foetus; hence the birth of a sterile heifer. I, 148, 151.

Frontal lobotomy: the oldest of neurosurgical operations, this consists in cutting the white substance of the frontal lobes transversally so as to isolate the cortex from part of the frontal lobe; today the preference is for operations adapted to each particular case, eg, either excision of certain convolutions of the brain (topectomies and cingulectomies), or destruction by stereotaxis of the fronto-thalamic association pathways and the thalamic nuclei. VII, 138.

Fucaceae (or fucales): an order of algae of which the most typical representative is the vesicular *Fucus*, very common on sea coasts. Its thallus has small vesicles full of gas (nitrogen) which enable the plant to float. III, 57, 58.

Functional disturbance: a disturbance without organic lesion, but with a constant anxiety component. Such are spasms, nauseas, vertigos, various pains and all other disfunctions. VII, 46.

Fungicide: a substance that destroys fungi. VII, 88.

Fungus: a plant characterized by the absence of chlorophyll pigment and consequently incapable of nourishing itself in autotrophic fashion. Fungi are thus saprophytes or parasites. The fungus class is very important for the number of different species that it contains, and is divided into lower fungi or Phycomycetes, of non-septate structure, and higher fungi or Eumycetes (Septomycetes), the structure of which is septate. III, 12, 19, 46, 48, 58, 59, 60; VI, 64, 65.

Fusarium: a lower fungus responsible for a plant disease called fusariosis. A species of *Fusarium* cultivated in the laboratory produces a plant hormone, gibberelin. III, 82.

G

Galactose: soluble sugar similar to glucose which is found in the natural state in milk, mucilage (gelose), and sugar beet. Industrially it is obtained by the hydrolysis of lactose. VI, 11; VII, 14.

Gall bladder: a pear-shaped reservoir continued by a small canal, the cystic canal, that joins the hepatic canal to form the common bile duct. Part of the hepatic bile secreted by the liver stays in the gall bladder and undergoes important modifications: the most evident phenomenon is a reabsorption of water which causes an increase in the concentration of dissolved substances which may reach ten times the initial concentration. A mucine secreted by the mucosa of the gall bladder passes into solution. The liquid resulting from these modifications is bile. VII, 21, 110.

Gametangium: the organ producing the reproductive cells, the gametes. This term is used mainly in botany. III, 58, 60.

Gametes: reproductive cells (spermatozoa produced by the male, ova or eggs produced by the female). I, 20, 143, 145; III, 13, 46, 47, 64, 66, 67.

Gametocysts: vesicles in which are formed the gametes of algae and fungi. III, 46, 47.

Gametogenesis: the formation of sexual cells called gametes (ova or spermatozoa). The general outline of gametogenesis includes a number of phases: (1) the germinative phase of division of the primary cells, leading to the formation of ogonia and spermatogonia; (2) the growth phase, from which result the cytes, spermatocytes or oocytes of the first order; (3) the division phase, including two successive divisions: (a) a reductional division (meiosis) that leads to gonocytes of the second order; (b) an equational mitosis producing the ovum or the spermatid. The ovum is the mature egg. In the male the spermatid develops into the spermatozoon (spermatogenesis). I, 109, 110.

Gametophyte: in plants without flowers, the name of a haploid individual on which gametes are formed. In mosses, for example, each gametophyte is a plant with leaves. In ferns and Phanerogams the gametophyte generation is extremely reduced. See Alternation of generation. III, 48, 49, 57, 66.

Gammaencephalography: a method of observation founded on the fact that certain substances marked by a radioactive isotope are fixed unequally on normal brain tissue and on tumours. After injection of the radioactive substance through a vein, an apparatus is used for counting the radiations emitted; this makes it possible to draw up a map showing the fixation of the radioactive substance in the brain and to suspect, by their anomalies, the presence and position of certain tumours. VII, 137.

Gamma-globulin: a variety of globulin contained in blood serum. The gamma-globulins are responsible for phenomena of immunity: most antibodies are gamma-globulins. I, 154; VII, 51, 71.

Gammagraphy, hepatic: radiography carried out by injecting into the circulation a radioactive body that is taken up by the liver and then recorded by the rays emitted by the latter. Thus a map of the liver is obtained. If there is a tumour or a cyst, this is shown by one zone being less radioactive than a neighbouring (mute) zone. Different radioactive substances are used, depending on the organ to be studied (kidney, liver, or brain). VII, 28.

Ganglion: see Nerve ganglion.

Gastrectomy: total or partial ablation of the stomach. VII, 105.

Gastroenterology: the study of the physiology and pathology of the stomach and intestine. VII, 35.

Gastrula: an important stage in the development of the embryo in metazoic animals, following the blastula stage. The method of formation of the gastrula, or gastrulation, varies according to species; the general feature is the folding (invagination) of a part of the blastoderm towards the inside of the central cavity, so that a sac with a double wall is formed, named the gastrula. Between the external layer (ectoderm) and the internal layer (endoderm) there soon appears an intermediate layer (mesoderm): thus the principal rudiments of future organs are brought into position. I, 73, 133, 134, 136; III, 12, 13.

Gel: a colloid in a semi-rigid state. I, 38, 39.

Gelatin: a substance with the appearance of a jelly found in the fibrous tissues of animals. IV, 60, 63.

Gelose, or agar: a mucilage extracted from a marine alga, commonly used to solidify culture media. III, 36, 83; IV, 60, 62.

Genealogical tree: a symbolic representation, shaped like a tree, of the succession in time of species or individuals descended one from another. I, 19, 21.

Gene exchange: an exchange between two bacteria of a small part of their genes, in the form of DNA. This exchange may be made by transformation, transduction, or recombination. IV, 31, 32.

Genes: the elements that make up the chromosomes, which are believed to be the biological units of heredity. Genes ensure the transmission of specific character from one generation to another. Each living being possesses an even number of chromosomes. It follows that each gene corresponds to a homologue or allele that is identical with it (homozygote), or different (heterozygote); in the latter case, one of the two alleles may be dominant or recessive. In principle, a given gene is always found on the same chromosome in a given place (locus); the sequence of genes on a chromosome is thus invariable; but if a chromosome undergoes rearrangement (eg, translocation) this will lead to a modification of hereditary character (and, eg, the appearance of 'chromosomic' diseases). In other cases, there is a sudden modification called a 'mutation' of a gene or a group of genes, either spontaneously or under the effect of a physical or chemical mutagenic agent. The exact nature of genes has not yet been elucidated; up to now electron microscopy has not shown the material existence of these particles. The view currently held is that these genes, carriers of genetic information, are made up of groups of the four bases (thymine, cytosine, guanine, and adenine) of DNA. I, 116, 118, 119, 122-126, 143, 145; III, 128, 129, 133, 134; IV, 34, 93; V, 139; VI, 11, 117, 138-140, 147.

Genetic code: the sum of coded information contained in the genes. By this means, under the control of DNA in the nucleus and by means of RNA messengers (see nucleic acid), the cytoplasmic centres of protein synthesis, microsomes, synthesize specific proteins, beginning with amino acids. The synthesis of each of the known amino acids requires the intervention of three of the purine bases of the pyrimidine bases of nucleic acid. I, 54.

Genetic information: determination of hereditary character of the organism by the genes contained in the nucleus of the cell. Today it is admitted that the active element of the genes is deoxyribonucleic acid (DNA), the innumerable combinations of molecular arrangement of which preserve genetic information. This is transmitted, by a mechanism that at the moment is still being sought, to ribonucleic acid (RNA) which, in the cytoplasm of the cell, directly controls the synthesis of protein. I, 53, 54, 159.

Genetic map or chart: see Chromosome map.

Genetics: relating to genes, that is to say, to the elementary particles of heredity; genetics is the science of the transmission of hereditary character. I, 115, 116; III, 138.

Genital ducts: tubular ducts connecting the genital organs to the external part of the body; their role is to conduct genital products, ova or spermatozoa, from the abdominal cavity where they are produced. Genital ducts exist in most animals that reproduce sexually. In the young mammal embryo, the genital ducts or channels are duplicated (Wolffian ducts and Mullerian ducts). In the male foetus only the Wolffian ducts persist, forming the vas deferens; in the female, only the Mullerian ducts persist, in the form of the uterus and Fallopian tubes. I, 144, 145, 146, 147, 148, 149, 150, 151.

Genital tract: the various parts of the genital apparatus (genital duct, glands and copulatory organs). I, 144, 148, 151.

Genome: the sum of the hereditary factors, or genes, carried by the gametes of an individual. I, 122, 124; IV, 30, 37; III, 67.

Genotype: see Phenotype.

Geotropism: orientation imposed by weight during the growth of the vegetative organs of a plant. III, 63.

German measles: an infectious disease caused by a virus, characterized by an eruption similar to that of measles and multiple adenopathies, especially cervical ones. It is dangerous in a pregnant woman because the child is often affected during its embryonic life (teratogenic action). VI, 143.

Germen: all the germinal cells that reproduce, in opposition to the soma, constituted by the remainder of the cells of the body. The germen is the physical basis of hereditary character. Transmitted from individual to individual and from generation to generation, the germen is potentially immortal. I, 73, 91, 102, 106, 111-114, 146, 151.

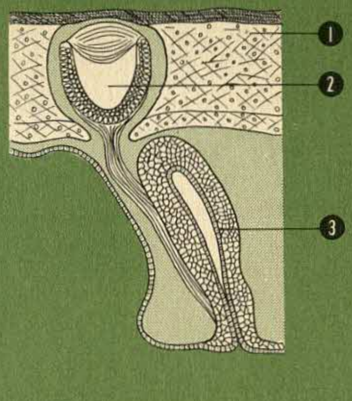
Germ layers: layers of cells that differentiate in the embryo from the first stages of development. The external layer or ectoderm forms the epidermis and the nervous system: the internal layer of endoderm, formed by a folding in towards the inside of the primitive hollow vesicle, supplies many of the visceral tissues. Between the two there appears—except in the most primitive forms, such as sponges—an intermediate layer, the mesoderm, origin of the skeleton and muscles. I, 134.

Gibberellin: a plant hormone produced by the fungus *Gibberella fujikuri*. It has the property of considerably stimulating the elongation of plants, thus causing the formation of giant specimens. III, 16, 82, 83, 86, 87, 89.

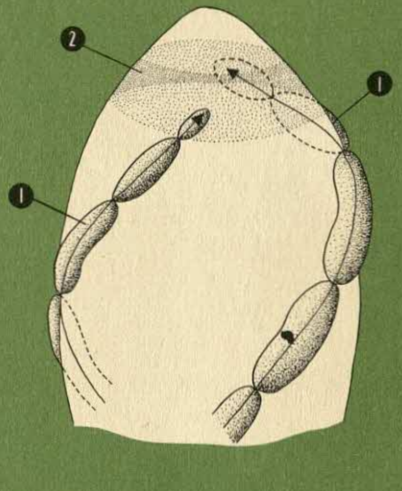
Glandular cell: a cell, usually of epithelial origin, that produces a secretion, eg, mucus-, sweat- and mammary-glands; or a cell belonging to an internal secretion gland (thyroid, pituitary, adrenal, etc.). I, 60, 61.

Glaucoma: an affection of the eye, marked by a strong intraocular hypertension. The eye becomes enlarged and shiny and the pain caused by this hypertension is usually unbearable. Untreated, glaucoma often leads to blindness because of optic atrophy. VI, 142.

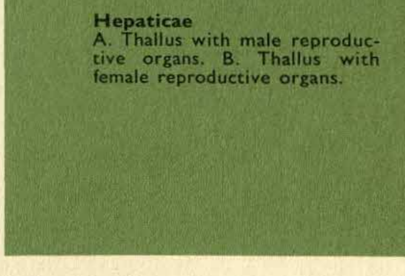
Gleysation: formation of a gley soil; that is to say, a horizon of soils, fairly deep, compact, grey and green in colour, with



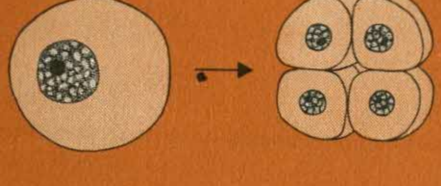
Hatteria (Pineal eye)
1. Parietal bone. 2. Pineal eye. 3. Pineal body.



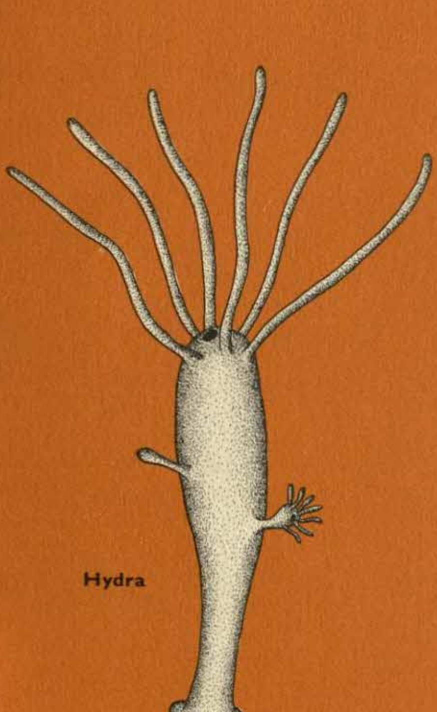
Helix, foliar
1. Foliar helices. 2. Initial ring.



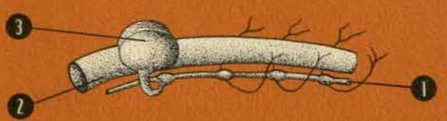
Hepaticae
A. Thallus with male reproductive organs. B. Thallus with female reproductive organs.



Holoblastic (ovum or egg)



Hydra



Hyponeurian
1. Central nervous system. 2. Digestive tract. 3. Cerebral ganglia.

impregnation of iron and manganese in a reduced state. III, 124.

Glioma: a tumour that develops in the neuroglia, connective tissue that supports nerve cells. VI, 144.

Globulins: plasma proteins insoluble in water. Electrophoresis enables globulins to be classified as alpha, beta and gamma. The level of total blood proteins is normally between 70 and 80 g per litre, that of albumens between 45 and 55 g per litre, that of globulins between 25 and 35 g per litre. VII, 28, 51, 62.

Glomerular capillary: a fine network of arterial capillaries situated in the glomerulus of the nephron. V, 22, 27.

Glomerular filtration: the first phase of the formation of urine, during which the glomeruli (small bundles of capillary vessels contained in the nephrons, which are elements of the kidney) retain about a fifth of the blood plasma that goes through them. This primitive urine is passed into the uriniferous tubules, where it undergoes various transformations before becoming the final urine. V, 22, 24, 26, 136; VII, 26.

Glomerulus: a renal organ of filtration in the kidney of vertebrates, constituted by a group of minute capillary blood vessels contained in an envelope of connective tissue known as Bowman's capsule. V, 21-23, 25, 26; VI, 89, 92, 95; mi.

Glossinia: flies of the genus *Glossina* in Africa, vector of sleeping sickness. VII, 75, 78.

Glucagon: a hormone secreted by certain cells of the islets of Langerhans of the pancreas, the action of which is the reverse of that of insulin: glucagon tends to raise the amount of blood glucose. VI, 105.

Glucocorticoid: see Adrenal cortex.

Glucose: a simple glucoside, with six carbon atoms, that constitutes the main substrate of cell respiration. It is also one of the first substances formed in photosynthesis. I, 39, 42, 43; III, 28; VI, 104, 106; VII, 14, 28, 84, 90.

Glucosides (or sugars): the generic name given to a group of substances found in living matter and that are mainly composed of carbon, hydrogen and oxygen; glucosides have the general formula of: $(CH_2O)^n$. Their main role is to supply energy and they are stocked in cells in the form of reserves: for example, glycogen in animal cells, starch in plant cells. The most simple glucosides consist of three, five or six carbon atoms: ribose, deoxyribose (five carbon atoms) are the constituents of nucleic acids. Glucose (six carbon atoms) is the normal substrate of cell respiration. The glucosides, of which the carbon atoms are a multiple of six, are called polysaccharides (cellulose and glycogen). Some, with a more complex structure, mucopolysaccharides, are the essential constituents of the cell membrane of bacteria. I, 38; 39; III, 153; IV, 24; VI, 55.

Glycaemia: the level of blood glucose. In man, the level is I gramme per litre; it is kept constant by a complex regulatory system. Variations of glycaemia are observed during certain diseases (the hyperglycaemia of diabetes, the hypoglycaemia of certain tumours of the pancreas). VI, 105.

Glycogen: a polysaccharide substance resulting from the union of a large number of glucose molecules. In the form of a reserve, in liver and muscle, glycogen is used in metabolic reactions each time the organism requires energy (in particular, in muscle contraction). V, 54; VI, 11, 14, 104.

Glycogenesis: the formation of glucose by hydrolysis of glycogen. This is kept in reserve in liver and muscle, according to the needs of the organism. I, 90; VII, 28.

Goitre: a benign thyroid tumour. This name is sometimes given to all swellings of the thyroid gland, whatever their nature; hence the terms cancerous, fibrous, cystic, parenchymatous and tuberculous goitres. VII, 15.

Golgi bodies: cytoplasmic organelles in the cell, of essentially lipidic nature, their exact role has not yet been determined. The Golgi bodies possibly play a part in glandular secretions. I, 61.

Golgi apparatus: a corpuscle in the form of a spindle, constituted by nerve endings and situated at the junction between a tendon and a muscle. The lengthening of the tendon causes a similar lengthening of the corpuscle and leads to nerve excitation that is transmitted to the higher nerve centres; these then top the lengthening of the tendon. The Golgi apparatus are therefore proprioceptors, or sensory receptors responsible for posture. V, 159; VII, 58; mi.

Gonad: a genital gland in which the germinal cells or gametes mature: the male gonad (testis) produces spermatozoa; the female gonad (ovary) produces oocytes or ova. I, 112, 113, 145, 146, 150; VII, 95, 96.

Gonad rudiment: part of the embryo which is the origin of the genital organs of the adult. The rudiment of the genital glands arises in the crest (genital crest) that is formed on the dorsal surface of the coelomic cavity. The rudiments of the genital ducts are contained in the Wolffian ducts and the Mullerian ducts. The outlines of the external genital organs lead to the adult organs. I, 144, 145, 146.

Gonadostimulin: a hormone secreted by the pituitary which stimulates the genital organs (ovaries and testes). I, 90; V, 137.

Gonids: the name given by Ederlein to small granules present in bacteria and behaving like gametes. The gonids are the first appearance of sexual phenomena in the ladder of evolution of living beings. II, 30.

Gonococcus: a bacterium responsible for gonorrhea; it is shaped like a kidney and generally coupled two-by-two on the concave side. IV, 58; VI, 14; VII, 85.

Gonoducts: in mammals, embryonic genital channels (Wolffian and Mullerian channels). I, 146, 150.

Gonorrhea: a microbial inflammation of the mucosa of the genital organs, caused by a gonococcus. VII, 85.

Gout: an affection characterized by an accumulation of uric acid crystals in the joints, the effect of a disorder of metabolism of the purine bases. VI, 11, 140.

Graafian follicle: a structure shaped like a small sac, situated on the surface of the ovary of mammals; it develops after puberty and in bursting liberates the ovum. A scar persists on the surface of the ovary after rupture of these follicles. I, 128, 130; VII, 35; mi.

Graft: an operation consisting in taking living tissues from an organism and placing them either in the same organism (autograft), or in another individual of the same species (homograft), or in an individual of a different species (heterograft). The graft is successful when it continues to live on the carrier of the graft. Though practised for a long time on plants, grafting in animals is impeded to different degrees by phenomena of immunity (unless the graft is of embryonic tissue). In higher vertebrates, only an autograft is possible. I, 108, 109; III, 19, 78, 80, 81; VI, 51, 121, 135; VII, 99, 114, 128, 131, 134, 139-141.

Graft, chorio-allantoic: a technique employed in embryology, consisting of including fragments of tissues (eg, buds of organs) in a membrane of a chick egg that is being incubated. The graft will continue to develop in this allantoic membrane independently of the organism from which it has been taken. I, 32, 33.

Gram-staining method: a method of staining microbes that consists in adding an iodized solution (Gram's fluid) to a preparation, already dyed with aniline (gentian violet). If this preparation is then washed with alcohol, certain microbes lose the colour (Gram-negative), while others remain more or less strongly coloured (Gram-positive). IV, 24-26, 46, 52, 121.

Gramicidin: see Tyrothricin.

Gram-negative and Gram-positive: see Gram-staining method.

Grana: corpuscles contained in chloroplasts formed by bundles of lamellae. It is the grana that contain all the chlorophyll of the green cells of plants. III, 25.

Granulia: an acute and generalized form of tuberculosis, characterized by the presence in the lung and in nearly all organs, of grey miliary granulations, the bacillus having invaded the organism through the blood. VI, 27.

Granulocyte: a synonym for polymorphonuclear cell. V, 34; VII, 98, 99.

Granuloma: a tumour with the appearance of a neoplasm and which causes the same phenomena, but is of inflammatory origin. (It may be specific and caused by tuberculosis or syphilis). VII, 31, 35.

Grey central nuclei: formations in the brain, constituted mainly by grey matter, developed partly from the mid-brain (the mesencephalon), partly from the end-brain (telencephalon) and including the optic thalamus and the striate bodies. V, 68.

Grey crescent: an area in the form of a crescent which, on the surface of the amphibian egg, differentiates itself very soon after fertilization (one or two hours). The grey crescent marks the future dorsal surface of the embryo. The middle of this zone, in which the blastopore hollows out (three days after fertilization) indicates the plane of symmetry of the embryo in course of development. The grey crescent owes its colour to the migration of black pigment that leaves the future area of the crescent and goes towards the point of entry of the spermatozoon. I, 131-134; mi.

Ground substance (or matrix): an amorphous gelatinous substance of a glucosidic nature present in all connective tissues and in which the cells are bathed. VI, 114, 115, 116.

Growing point: part of the terminal meristem of a plant, formed like a ring. The growing point is the seat of intense mitotic activity (see Cell division) which gives rise to the budding of leaves. III, 62.

Growth factor: a nutritive factor in the absence of which any given organism is incapable of growing or multiplying and which the organism cannot, by itself, synthesize. Such are vitamins, essential amino-acids and certain metallic trace elements. III, 82, 86, 87; IV, 60, 62, 65.

Gymnosperms: a sub-branch of the phanerogams, gymnosperms are characterized by their uncovered ovules, often carried in a cone on the margin of a carpel leaf. III, 50, 52.

H

Habitus: the external aspect, ie, all particularities showing the individuality of an organism. I, 85.

Haemagglutinin: a protein substance present in certain viruses, such as the influenza virus, which has the property of producing agglutination of red cells owing to its specific action on mucopolysaccharides of the membrane of these cells. The phenomenon of haemagglutination is one of the means most used to show that certain viruses are present, in particular those of influenza and mumps. IV, 95.

Haematocrit: an apparatus for measuring the volume of red cells in relation to the blood. It is made of a glass tube about 11 cm long, in which the mass of red cells is separated from that of plasma by centrifugation. The volume of red cells is normally 40 to 45 cc per 100 cc of blood in man and 38 to 42 cc in women. By extension, this term is applied to the volume of cells itself. VII, 31, 53.

Haematoma: an internal leakage of blood following a breakage of a vessel. Generally, haematomas are reabsorbed by themselves; in certain very rare cases they have to be removed surgically. VI, VII passim.

Haematopoiesis: the production of blood cells (red cells or erythrocytes, white cells or leucocytes, platelets or thrombocytes) by the haematopoietic organs (bone marrow, spleen, and lymph nodes and the reticular system). I, 90; V, 30, 137; VI, 120; VII, 31, 90, 95, 97.

Haematopoietic organ: the organ that forms blood cells. In the embryo, these organs are the liver, the spleen, and the bone marrow. In the adult, only the bone marrow preserves its haematopoietic role. VII, 31, 90, 91, 95, 96, 98, 101.

Haematosis: the transformation of venous blood in the respiratory apparatus into arterial blood by means of oxygenation. VII, 61, 62.

Haem: an organic molecule that ensures respiration. Joined with a protein (globin) haem forms haemoglobin, respiratory pigment of the red cells. Haem is formed by a central atom of ferrous iron surrounded by four pyrrolic nuclei. III, 25, 34.

Haemiplegia: paralysis of only one side of the body, affecting the upper limb or the lower limb on the same side; it is due to a central lesion in the brain on the opposite side to the one affected. It may be produced either by vascular haemorrhage, by the pressure of a tumour, or by traumatic shock produced by an accident. VII, 130.

Haemodynamic data: information obtained by measuring the forces present in blood circulation. VII, 59, 118, 121.

Haemoglobin: a respiratory pigment contained in red cells of all vertebrates and certain invertebrates (eg, Holothuria, Annelida, and certain parasitic worms). Haemoglobin, with the iron atom contained in its molecule, can temporarily combine with atmospheric oxygen, and then give it to the cells of the organism in the blood capillaries. I, 71; IV, 124; V, 18, 31, 42; VI, 42, 47, 78, 80; VII, 25, 51.

Haemolysis: loss of haemoglobin from the red cells, which diffuses into the blood plasma. Haemolysis may be caused by physical or chemical deterioration of the red cells, by a lowering of osmotic pressure of the blood, by substances called haemolysins (mainly antibodies), and by poisons such as cobra venom. I, 47; V, 43.

Haemolytic disease (also called constitutional haemolytic jaundice): a congenital illness transmitted as a dominant hereditary character showing an anomaly of maturation of the red cells: these are spherical, not discoidal, and their destruction is excessive. The disease is clinically marked by a haemolytic jaundice, anaemia and splenomegaly. Splenectomy will suppress most of its manifestations but will not cure it. V, 39, 40.

Haemolytic disease of the new-born: a disorder caused by iso-immunization of the material foetus resulting from incompatibility between the infant belonging to a Rhesus positive group, or more rarely to an A, B or AB group, and the mother belonging to a Rhesus negative, or more rarely, O group. Synonyms: familial erythroblastosis of the foetus and of the new-born. V, 40; VI, 82; VII, 30, 31.

Haemophilia: a congenital tendency to haemorrhage, resulting from the absence in the blood of a factor required for coagulation (anti-haemophilic factor A or B). Haemophilia is transmitted by sex-linked heredity. Women, heterozygous for the abnormal gene, carry this gene on one of the X chromosomes. This disease, which is transmitted by women, only affects males. V, 35, 36.

Haemophilus influenzae (Koch-Weeks bacillus): a bacillus present in the sputum of influenza patients (it is associated with influenza virus), or in the spinal fluid in the case of meningitis. It was observed by Pfeiffer in 1893, who noticed that the bacillus could only develop in the presence of blood. This bacillus is Gram-negative. IV, 39, 65, 66.

Haemorrhage: loss of blood following a wound or breakage of a vessel. VI, 22, 109, 132, 133; VII, 52, 53, 57, 109.

Haemostasis: stoppage of a leakage of blood caused either by an external haemorrhage or an internal haemorrhage of a vessel. V, 35, 36, 37; VII, 53, 105, 136.

Haemostatic plug (or white thrombus): a clot composed solely of blood platelets (or thrombocytes) formed when minute vessels are broken. V, 36, 37; VII, 52.

Hageman factor (or contact factor): an activator of coagulation that only comes into play when the wall of a vessel is broken. V, 36.

Halophilic: appertaining to an aquatic organism adapted to living in water with a high saline content. IV, 74.

Halotolerant: an aquatic organism that can live in fresh water as well as in salt water by adjustment of its internal osmotic pressure. Many migratory fish, such as salmon and eels, come into this category. IV, 74.

Haploid: a cell that has only a single assortment of chromosomes, as opposed to diploid cells, which possess two: apart from rare exceptions (male bees), the only haploid cells of an organism are the reproductive cells (gametes), resulting from meiosis. I, 119, 120, 124; III, 16, 17, 57, 64, 66.

Hare-lip: all congenital malformations of the face arising from a defect in the joining of the facial buds, the line of join being apparent or a fissure persisting. This deformity often shows itself as a single fissure of the upper lip, or one that involves the arch of the palate. VII, 139, 141.

Hatteria (or *Sphenodon punctatum***):** a New Zealand reptile about 70 cm long. It has a number of very archaic anatomical characters and a pineal eye. I, 17, 18; mi.

Headache: a common symptom in numerous illnesses.

Heart-lung machine: an apparatus which replaces blood circulation and respiration when the heart has been temporarily put out of circuit. It is used in experimental physiology and in medicine for hole-in-the-heart operations. Blood circulation is ensured by a pump and is relieved of its carbon dioxide and enriched with oxygen by being passed through an artificial membrane imitating the wall of the lung alveoli. I, 80, 81; VII, 51.

Heliotherapy: therapeutic use of solar rays (ultraviolet rays) on part or the whole of the body. VII, 146.

Helobiae: an order of monocotyledous plants, which are for the most part aquatic (*Elodea* and *Potamogeton*). III, 55.

Hemichordates: organisms with a dorsal nervous system similar to that of the chordates, but without a true notochord. They are divided into two classes: the Enteropneusts and the Pterobranchia. II, 18.

Henle's loop: part of the tubule of the nephron in the form of a hair-pin. Situated between the proximal segment and the distal segment of the tubule, Henle's loop is constituted by a narrow descending segment and a wider ascending segment. From the histological point of view it is formed of flat cells with no specialized brush-border surrounding a wide lumen. V, 21.

Heparin: a substance that has an anti-coagulant effect on blood. Heparin is produced by a number of tissues, but (as its name indicates) mainly by the liver. V, 34, 37; VII, 131.

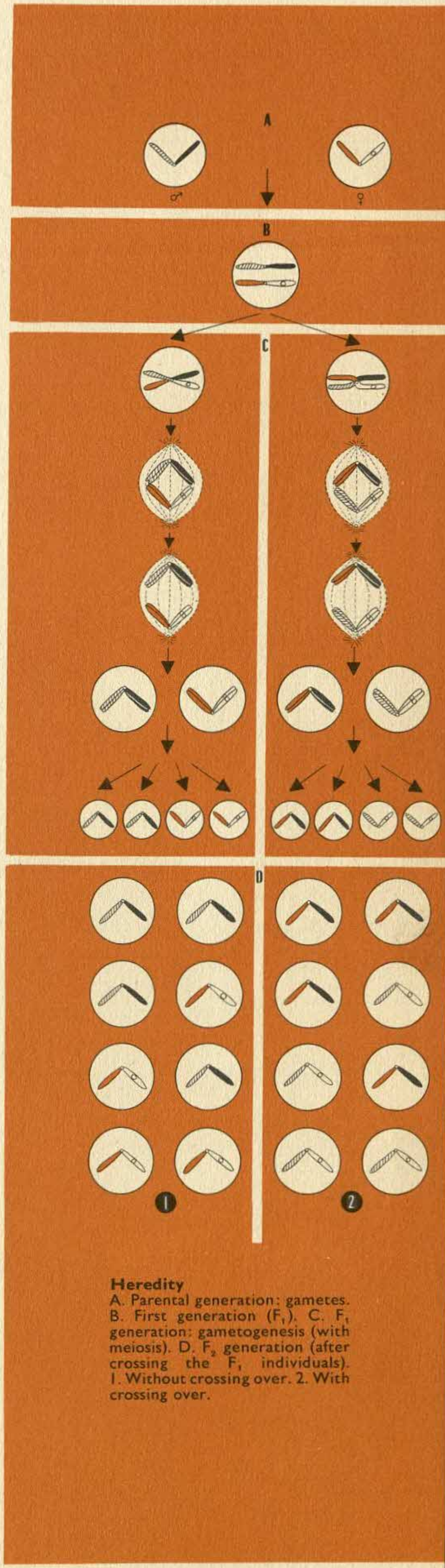
Hepatectomy: excision of part of the liver: total excision is impossible, the liver being essential for the functioning of the body. VII, 110.

Hepaticae: a class of plants close to the mosses and forming with these a branch of the Bryophyta. The Hepaticae, like the mosses, undergo a cycle of development with alternation of two generations. The most typical Hepaticae (*Marchantia*) have no leaves, but have a thallus. III, 57.

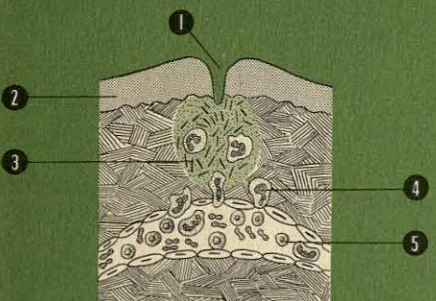
Hepatomegaly: hypertrophy of the liver.

Hereditary character: a specific character (morphological or physiological) transmitted from generation to generation in accordance with the laws of genetics. It is on hereditary character that the concept of species is based. I, 23, 115 et seq; III, 129, 130; IV, 122.

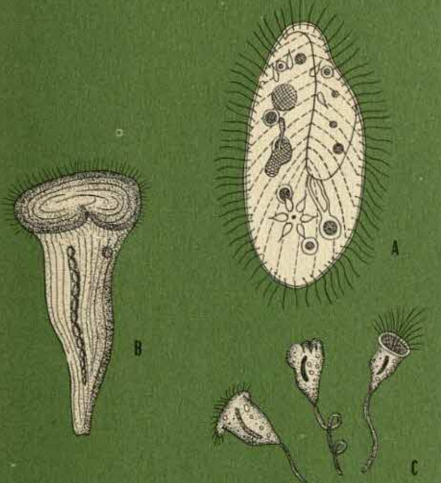
Heredity: transmission from one generation to the next of specific characters conveyed in the genome of a living organism. This transmission is not made at random, but according to certain fundamental laws (Mendel's laws) on which genetics, the science of heredity, is based. The first law is that of the segregation of characters inherited from each parent: in crossing living beings that differ only by a single character, in the first generation uniform hybrids are obtained and in the second generation there will be 50% hybrids, 25% will have the character of one of the parents and 25% will have the character of the other parent. This law is explained by the existence of chromosomes that carry genes and by the fact that each hereditary character depends on a well-defined gene having a fixed place on the chromosome (locus). At the formation of the gametes, the two chromosomes of each pair separate in the final phase of meiosis; each gamete then carries only half the genome of the individual, hence the segregation of characters. If the chromosomes simply separate, the individuals of the second fillial generation will inherit all the characters of one parent or the other. But in fact, in the chromosomes that are paired during the course of meiosis (zygote stage) an exchange of genes takes place: this is a crossing-over or re-combination of homologous parts of the chromosomes. If two homologous genes of the same pair of chromosomes are identical, it is said that the individual is homozygous for this gene; if the two genes are different, the individual is heterozygous for this gene; the different mutants of the same gene are called alleles. Most often, in the heterozygote, one of the alleles is dominant, the other recessive and masked in the second fillial generation in hybrid individuals. This explains the apparent disappearance of certain hereditary characters: eg, the crossing of a grey mouse (dominant character) and a white mouse (recessive character) will produce only grey mice in the first generation; in the second generation, 75% of the mice will be grey and 25% white (homozygous for the white recessive character). The 75% of grey mice will include 25% of homozygous mice for the grey character and 50% hybrid mice heterozygotes, in which only the dominant character is shown. If varieties of the same species, but differing in several ways in their hereditary characters, are crossed, each pair of characters behaves as if it was independent, as a result of which a large number of possible combinations may occur in hybrid descendants: this is Mendel's second law of independent assortment. The laws of segregation and hybridization always apply when dealing with hereditary characters carried by chromosomes, that is to say, nuclear heredity. But if dealing with more complex mechanisms, such as cytoplasmic heredity, then cell division shows that certain cytoplasmic bodies are also divided and the daughter elements pass in the cytoplasm to the two cells that result from the division: this is the case with chloroplasts



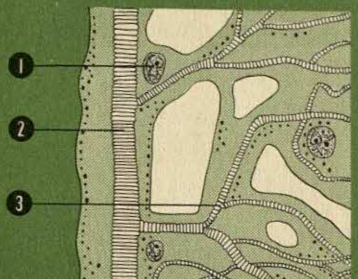
Heredity
A. Parental generation: gametes. B. First generation (F_1). C. F_1 generation: gametogenesis (with meiosis). D. F_2 generation (after crossing the F_1 individuals). 1. Without crossing over. 2. With crossing over.



Inflammation
1. Wound. 2. Skin. 3. Microbes. 4. Leucocytes. 5. Blood capillary.



Infusoria
1. Paramecium. 2. Stentor. 3. Vorticella.



Insect (trachea)
1. Tracheal cell. 2. Trachea. 3. Tracheole.

or, in Protista, with certain bodies situated at the bases of the flagella or the cilia, and a cytoplasmic factor which, in *Drosophila*, transmits carbon dioxide sensitivity. Other cases of cytoplasmic heredity are less well defined: there are those, carried by the female gamete, that affect the first stages of development of the embryo after fertilization. I, 115-126, 145; III, 129-130; V, 38-40, 139; VI, 83, 88, 116-118, 135, 138-140, 146; mi.

Hereditary factor: see Hereditary character.

Hermaphrodite: flowers possessing both male organs, or androecia (stamens), and female organs or gynaecea. Such flowers may or may not be fertile. III, 131.

Hermaphroditism: coexistence of sexual characters of the two sexes in one individual. In certain species, the same organism carries the gametes of the two sexes, either produced in separate glands or in the same gland. This is simultaneous hermaphroditism (eg, the snail). In other species the individual, during the course of its adult life, passes from one sex to the other. This is successive hermaphroditism (eg, some types of oysters). In some fish, old females transform themselves into functional males. But in all other vertebrates, hermaphroditism (or intersexuality) is only observed in certain pathological cases. I, 113, 114; III, 128, 131.

Hermit-crab: a crustacean resembling a prawn that places its soft body in the empty shell of a gastropod. This shell is often surmounted by a sea anemone (actinia) or a colony of hydroids with which the hermit-crab forms a biological association. II, 106.

Herpes: cutaneous lesions. In herpes simplex a spore vesicle develops on the lips or the fingers, often following a fever. Herpes zoster, or shingles, is a disease caused by a neurotrope virus characterized by development of small vesicles in a given area corresponding to a zone innervated by a nerve (unilateral eruption). VI, 19, 23, 51.

Heterochromosome: a chromosome that determines sexual differentiation. In one of the sexes (male for mammals), heterochromosomes form a dissimilar pair, which are designated by the letters X and Y; the cells of the female contain two X chromosomes. I, 113, 143-145.

Heterograft: transplantation of tissues of an individual of one species to an individual belonging to another species. I, 83.

Heterosis: in genetics this designates the vigour of the first hybrid generation. This property is used for the selection of animal or plant varieties that show certain particular characters. III, 131, 132.

Heterostyle: a character of certain plants that have two types of flower: in the first type, the extremity of the ovary, called the style, is long and protrudes above the tip of the stamens; in the second, the style is shorter than the stamens. II, 130.

Heterotrophic: incapable of synthesizing organic substances from mineral elements, and consequently, obliged to feed on organic substances made by autotrophic organisms. I, 68, 70; III, 11, 23, 24; IV, 64.

Heterozygote: an individual in which two homologous genes (two alleles) carried by the two chromosomes of the same pair are different: one of the two genes may be dominant, the other recessive. The opposite of homozygote. I, 118; II, 144; VI, 139, 140.

Hexosamine: a derivative of a sugar with six atom carbons on which is fixed an amine radical (NH_2); eg, glucosamine and galactosamine. IV, 24, 25.

Hexose: a generic name of glucosides with six carbon atoms (such as glucose and fructose). The hexoses are made by green plants, by means of photosynthesis. III, 22.

Hibernation: a particular physiological condition in which certain homoeothermous animals (eg, the beaver) pass the winter by modifying their thermal regulation so as to endure a considerable lowering of their central temperature with a slowing down of metabolism. By extension, this term has been applied to the medical techniques of hypothermia, used especially in surgery. V, 154; VII, 57, 119.

Hippocampus: a nerve structure belonging to the 'ancient brain' of vertebrates (rhinencephalon): in man, the development of the neo-cortex has pushed it back to the internal surface of the cerebral hemispheres. Lesions of the hippocampus lead to intense character-disturbances and lapses of memory. V, 86, 87, 88.

Histamine: a chemical substance which in animal organisms stimulates secretions and acts on smooth muscle; it is a powerful vasodilator. It is present, no doubt in the form of an inactive precursor, in all animal and plant cells. The sudden production of histamine, which originates in the reaction between antigen and antibody, determines the appearance of allergic phenomena such as urticaria, asthma and Quincke's oedema. V, 92; VII, 68, 70.

Histoblast, somatic: see Somatoblast. I, 110.

Histochemistry: the microscopic study of chemical constituents of the living cell. Histochemistry uses specific chemical reactions that enable a precise intracellular localization to be made. I, 50, 59.

Histology: the study of tissues (q.v.).

Histones: proteins that are slightly alkaline, soluble in water and can be coagulated by heat. They contain about 15% of diamino acids. I, 124.

Histoplasmosis: a tropical mycosis, frequent and often fatal in children, characterized by anaemia, fever, hepato- and splenomegaly, respiratory accidents and digestive or cutaneous disorders, due to a fungus (*Histoplasma capsulatum*). VI, 64.

Historadiography: the application of radiography to the histological study of tissues. I, 58, 63; VII, 29.

Hodgkin's disease: malignant lymphogranulomatosis, a disease characterized by superficial adenopathies of the body (cervical, axillary, and inguinal) and deeper ones (metiastinal and retroperitoneal). It produces itching, undulant fever and enlargement of the spleen. It is diagnozed by biopsy of the lymph nodes, which reveals large characteristic cells called Sternberg's cells. The disease is always fatal within a few years. VII, 31, 90.

Homoeostasis: maintenance of the constancy of the internal environment (blood and lymph) and integration of an organism by means of a number of automatic internal regulators. In a homoeostatic organism, every effect results in cybernetic control reacting on its cause (feed-back). Homoeostasis depends on two large co-ordinating physiological systems, the nervous system and the hormonal system. In the organs and the walls of the blood vessels there are localized nerve centres (intereceptors) specially adapted to maintaining the constancy of the internal environment. For instance, arterial pressure is automatically regulated by baroreceptors (sensitive to pressure) arranged along the length of the vessels. Respiration is regulated automatically by means of the carotid sinus (chemoreceptor), which is sensitive to the amount of carbon dioxide in the blood. Glucose and sodium chloride in the blood are maintained at a constant level by the combined effect of hormonal mechanisms that compensate automatically as soon as the slightest falling off takes place. The part of the brain responsible for homoeostasis is the reticular formation. V, 23, 55, 83, 94, 95, 155; VI, 48, 93; VII, 42, 50.

Homoeothermy: the ability of animals, birds and mammals to keep their central temperature constant. Homoeothermy is one of the elements of homoeostasis, ie, the constancy of the internal environment. It is ensured in man by regulatory mechanisms that oppose any variations of central temperature (vasomotricity, sweating, and shuddering). V, 148.

Homochromy: the technique of animal camouflage. The animal covers itself with the colours of its environment and thereby becomes difficult to distinguish (eg, the chameleon, the ray). II, 120, 123.

Homogenization: a term in chemistry used by doctors with reference to the homogenization of elements taken for direct examination, especially of sputum. The structure of sputum is not homogeneous, and a sample of it may yield a part free from bacilli, though there may be some in another sample; homogenization gives equal chances of finding out whether there are bacilli in different parts. The technique is chosen according to the volume of the product to be examined. VII, 38, 40.

Homograft: the transplantation of tissues of one individual to another belonging to the same species. I, 83; VII, 140.

Homologous organs: organs of a similar nature, but fulfilling different functions, eg, foliated stamen and leaf; petal and petaloid stamen. III, 51.

Homozygote: an organism that has received from its two parents, for a given hereditary character, two identical genes situated at the homologous loci of the same pair of chromosomes. I, 118; II, 143, 144; III, 130; IV, 124; VI, 139, 140.

Horizon: a term used in soil science meaning stratum of soil, such as may be discovered in a vertical section taken in natural soil. III, 124; IV, 77.

Hormone: a chemical substance produced in very small quantities by an organ and which has the property of controlling the physiological functioning of another organ. Most often, the organ thus affected will also be secreting a hormone, and so there is thus either a chain-reaction or a feed-back reaction, as a result of which the stimulated organ exercises control on the stimulating one. Hormones are thus 'chemical messengers' that ensure most of the automatic regulations of the function of multicellular organisms. Hormones are generally produced in specialized organs, the endocrine glands, that put out the product of their secretions into the circulating internal environment, ie, the blood; these organs include the pituitary, the thyroid, and the adrenal glands. In other cases, inside an organ that has another physiological function, there are groups of cells that secrete a hormone, such as the pancreas, a gland which is both exocrine (digestive enzymes) and endocrine (insulin and glucagon). In recent years it has been shown that when the organism requires them, 'local' hormones are produced in the blood or the tissues themselves, such as, for example, bradykinine, the effect of which is to dilate the blood capillaries and stimulate smooth muscle locally. Hormones, especially well known in vertebrates, are perhaps present in the whole living realm, but up to now they have been found in invertebrates only in certain groups (annelids, molluscs, and arthropods). In the plant world, certain growth factors that work in low concentration and at a distance have been compared with hormones. II, 45, 46; IV, 125; V, 23, 48, 49, 50, 52, 54, 55, 57-59, 122, 134; VI, 96-99, 102, 103, 106, 107, 120, 127, 129, 130, 134, 135; VII, 16, 97.

Host: a living plant or animal organism on which a parasite lives. II, 105; IV, 87.

Hyalinization: degenerative transformation of cells and elements of connective tissue. I, 145, 146; II, 62.

Hyaluronidase: an enzyme that specifically attacks hyaluronic acid which is a fundamental element in connective tissue. Hyaluronidase is present in certain strains of streptococci and staphylococci, which explains the diffusion of toxins secreted by these micro-organisms. VI, 50.

Hybridization: the crossing of different races or varieties. Hybridization is one of the oldest techniques of selection and improvement of animal or plant species; hybrids can preserve certain qualities derived from their two parents. III, 126-132, 134.

Hydra: a fresh water polyp, belonging, like sea anemones and corals, to the phylum of the coelenterates. It has a shape like a tube 15 mm high, of which one extremity, the foot, is fixed to a support and the other, the mouth, is surrounded by tentacles. The freshwater hydra is the most typical example of an animal organism capable of reproducing indefinitely by continued budding. I, 102, 107-110; mi.

Hydrocortisone: see Adrenal cortex.

Hydroelectric equilibrium: the hydrostatic and electrolytic equilibrium between different cell compartments, extra-cellular and vascular compartments on the one hand, and intakes (water and mineral salts from nourishment) and outputs (transpiration, urine and faeces) on the other. 50% to 70% of body weight (according to age and stature), are represented by water. Hydroelectric equilibrium is maintained by a very delicate balance between the entry and exit of water. VII, 50, 51.

Hydrogen: one of the fundamental constituents of living matter, hydrogen represents 10% in weight of the human organism. It is present in organic compounds and in water. Hydrogen is freed during cell respiration. Krebs' cycle (q.v.) liberates five pairs of hydrogen atoms. Hydrogen is then carried by a chain of bodies called 'hydrogen transporters' and this leads to the formation of water in the presence of oxygen. This reaction of oxidation-reduction releases energy that is mostly stored in the form of energy-rich bonds in mineral phosphates (ATP and ADP). VI, VIII passim.

Hydrolysis: decomposition of a chemical substance by the action of water with incorporation of the constituents of water (hydroxyl ion OH^- and hydrogen ion H^+ in the two portions of the substance thus split. Hydrolysis is called chemical when it is produced under the effect of a chemical substance (acid or base); when an enzyme is involved with the chemical substance to be degraded it is called enzymatic. IV, 60, 62.

Hydroponic: the technique of cultivation without soil. Hydroponic plants are grown either in water or in gravel. III, 139, 140.

Hydrotherapy: see Crenotherapy.

Hyperazotaemia, or hyperuraemia: an accumulation of urea (a product of nitrogen excretion) in the blood, produced in most cases by renal insufficiency. (Urea constitutes the major part of blood nitrogen and is a reflection of the retention of nitrogen products in protein catabolism). VI, 51.

Hyperchromic anaemia: an anaemia characterized by a diminution in the number of red cells, but each red cell fixes a larger quantity of haemoglobin. VI, 78, 79; VII, 31.

Hyperglycaemia: a concentration of blood glucose higher than the normal level, which is I gramme per litre. Hyperglycaemia is a symptom of diabetes. In this disorder, the more severe the diabetes the higher the glycaemia. The correction of hyperglycaemia may be achieved by hypoglycaemic substances taken orally (sulfonamides) or insulin injected intravenously or subcutaneously. V, 137; VI, 105.

Hyperleucocytosis: an increase in the number of white cells or leucocytes in the blood (normally, in the adult, between 6,000 and 8,000 per mm^3 of blood). A large number of acute infections or chronic infections are accompanied by hyperleucocytosis (8,000 to 20,000 mm^3). On the other hand, abnormal proliferation of white cells in the blood—sometimes reaching figures as high as 50,000, 100,000 or 200,000 per mm^3—is generally evidence of leukaemia. VII, 31, 101.

Hypermetropia: an anomaly of the eye in which the image of an object situated at infinity forms beyond the retina. Hypermetropia may be due to insufficiency of convergence of the lens or to too small a dimension of the diameter of the back part of the eye. In such a case, hypermetropia is called axial. It is corrected by the use of biconvex convergent spectacles. VI, 142.

Hyperparasite: a parasite of an organism that is itself a parasite. This phenomenon is observed in insects. II, 154; III, 71.

Hyperplasia: excessive proliferation of cells, leading to hypertrophy of certain organs. III, 69, 71; VII, 29, 31, 34.

Hyperploidy: a characteristic of cell nuclei carrying a larger number of chromosomes than the normal $2n$ (the normal nucleus is called diploid). I, 106.

Hyperpnoea: more rapid or deeper respiration than normal respiration (eupnoea). V, 137, 139.

Hypersensitivity: a pathological condition due to the excessive reaction of an organism in whose internal environment a foreign substance has penetrated which behaves like an antigen; such a substance may be introduced into the blood, either directly by injection (serum or drug), or through lung alveoli (dust and pollens), or by repeated contact through the pores of the skin. In an organism thus 'sensitized', an antibody is formed which corresponds to the invading particle and each time that such an organism is placed in contact with the substance that has produced the state of hypersensitivity, a violent reaction occurs which is shown by oedema, urticaria, or asthma. This disorder is often called an allergic reaction. All individuals of the same species do not act in the same fashion to any given allergenic substance: the predisposition to hypersensitivity is a hereditary character, but it may show itself in descendants of a hypersensitive individual by various allergic phenomena: for example, the offspring of an asthmatic will not necessarily be asthmatic, but will perhaps show cutaneous hypersensitivity and a strong tendency to eczema. There are two kinds of hypersensitivity, which may coexist in the same individual: immediate hypersensitivity or anaphylaxis and delayed hypersensitivity. Immediate hypersensitivity is linked to the presence of thermostable circulating antibodies (allergens) and is released when these antibodies are placed in the presence of an excess of antigen. The sudden reaction, often fatal, is called anaphylactic shock. It is caused by the instantaneous liberation of large quantities of histamine in the organism. Since the discovery of anti-histamines, it is possible to protect sensitive subjects from anaphylactic shock. Another form of immediate hypersensitivity is asthma, a disease caused by chronic inflammation of the respiratory apparatus. In delayed hypersensitivity, the symptoms of intolerance after reinjection of antigen into a sensitized individual only appear after a certain delay (from a few hours to twenty-four hours). This form of hypersensitivity is then shown by a local inflammatory reaction that disappears in two or three days; this is what occurs after bacterial or viral infections (pneumonia, diphtheria, mumps, measles, etc.) and in the case of intolerance of drugs or food. It is retarded hypersensitivity that occurs also in the rejection of homografts: the receiver is not prepared and is in a state of retarded hypersensitivity towards the antigens contained in the graft. The mechanism of delayed hypersensitivity is still obscure; it is known, however, that there are no circulatory antibodies. It is perhaps a matter of new properties acquired by the cells themselves. Delayed hypersensitivity is concerned with phenomena of cellular immunity about which very little is yet known. III, 71; IV, 136, 137; VI, 14, 48-51, 53-57, 116; VII, 16, 66-68, 94, 96.

Hyperthermy: a body temperature that is above normal. In man, hyperthermy may have a number of causes (fever, increase of external temperature, and intense muscular work). Hyperthermy releases a certain number of regulatory phenomena (sweating, and peripheral vasodilatation) that aim to bring the central temperature back to normal. V, 151, 154; VII, 56.

Hyphae: filaments lacking chlorophyll that constitute the fundamental element of the body of a fungus or a lichen. I, 125; III, 48.

Hypnotics: drugs that ensure calm and restful sleep analogous to natural sleep. They act by inducing a depressive effect on the central nervous system. VII, 54, 150.

Hypochromic anaemia: an anaemia characterized by a diminution in the number of red cells, with a more marked lowering in the level of haemoglobin. (Antonym: hyperchromic anaemia). VI, 79, 80; VII, 31.

Hypoglycaemia: a fall in the level of blood glucose below its normal value (1 g/litre). V, 71, 72.

Hyponeural: an animal in which the nervous system, except the brain, is placed ventrally to the digestive tract. All invertebrates provided with a nervous system are hyponeural, except the prochordata (*Ascidia* and *Amphioxus*). The contrary is epineural. II, 17, 18; mi.

Hypophysis: see Pituitary.

Hypophysectomy: excision of the pituitary gland. VI, 94.

Hypoplasia: a diminution in the proliferation of cells and tissues, leading to the degeneration of certain organs. VI, 117.

Hypotension: a lowering of arterial pressure below the mean average value (less than 100 mm of mercury). It is observed in certain states of fatigue or overwork and in Addison's disease. VII, 121.

Hypothalamus: the ventral region of the diencephalon at the base of the brain, situated under the thalamus and close to the pituitary. It is composed of grey nuclei that are very important: the centre of co-ordination of activity of the sympathetic system, the centre of thermal regulation, and the sleep centre. I, 88, 90; V, 55, 87; VI, 87, 111.

Hypothermy: the state of an organism in which the central temperature is lower than normal. In homoeotherms, a certain number of mechanisms are adapted counter to hypothermy (shuddering, peripheral vaso-constriction, increase of metabolism). Hypothermy may be produced in surgery by refrigeration of the blood. See Hibernation. V, 154; VII, 57, 119-121, 126, 127, 136.

Hypoxaemia: a condition of oxygenation of the blood, lower than normal. Hypoxaemia is produced by all causes of asphyxia, including altitude. V, 72, 148.

Hypoxia: a slight diminution in the amount of oxygen distributed to the tissues by the blood. When this diminution is marked it is called anoxia. VII, 108.

Hysterectomy: total or partial excision of the uterus. IV, 154; VII, 110.

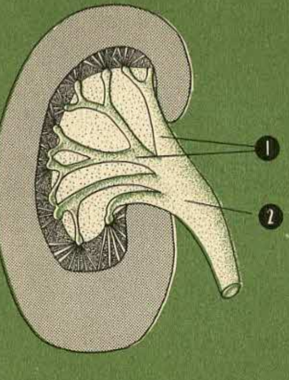
I

Icterus: see Jaundice.

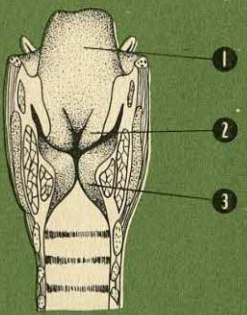
Idiosyncrasy: see Allergy.

Imago: a stage of perfect insect which has accomplished its development and completed its metamorphoses. II, 41, 42.

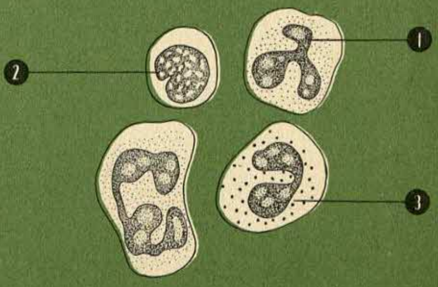
Immune serum: a serum containing antibodies obtained as a result of inoculating a laboratory animal with a micro-organism. Antibodies are specific and in bacteriology the use of immune serum makes it possible to determine the nature of an unidentified bacterial strain. IV, 55, 58.



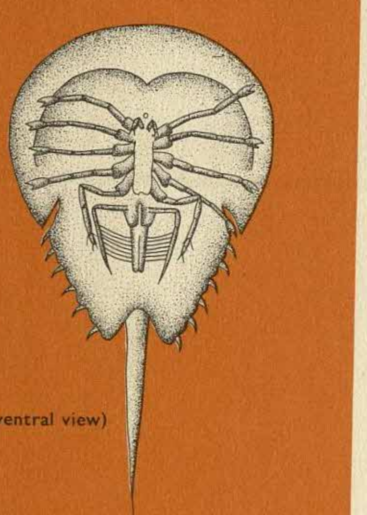
Kidney
Section showing the calices (1) and pelvis (2).



Larynx
1. Epiglottis. 2. False vocal cords (vestibular fold). 3. True vocal cords (vocal fold).

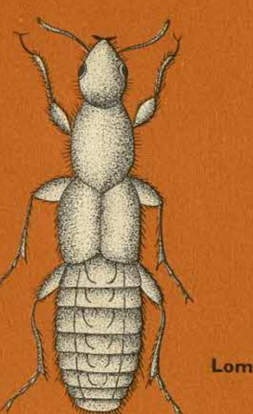


Leucocytes
1. Polymorphonuclear neutrophil. 2. Monocyte. 3. Polymorphonuclear acidophil.



Limulus (ventral view)

Liver fluke



Lomochusa

Immunity: a property possessed by certain individuals of being exempt from apparent pathological manifestations when subjected to the action of a determined pathogenic cause, whether poison, toxin or microbe. Immunity may be natural, or acquired spontaneously or by therapeutic action. It is most often exerted through the body fluids, although it is sometimes in the tissues or the cells (especially in viral affections). It is the cell system itself that provides its defence against pathogenic infection. IV, 21, 130, 142; VI, 23, 30; VII, 79, 82.

Immunochemical reaction: a precipitation reaction observed when, for example, a soluble antigen is placed in contact with a serum that includes the antibody corresponding to the antigen. I, 153.

Immunochemistry: a branch of chemistry that studies reactions linked to the formation of antibodies and the acquisition of immunity. I, 78; IV, 106, 110.

Immunological identification: laboratory procedures that permit the identification of a micro-organism by the use of antigen-antibody reactions. IV, 96.

Inclusion body: an infectious corpuscle particular to insects and constituted by viral particles surrounded by a protein envelope. Inclusion bodies are responsible for insect diseases known as polyhedra diseases. II, 158.

Incubation phase: the time that elapses between the period of contagion and the appearance of the first characteristic sign of a disease. VI, 22.

Indicators, acid-base: substances that change colour according to the degree of acidity or alkalinity of the environment into which they are put, eg, litmus paper, methyl orange, or phenolphthalein. IV, 54, 58.

Induction: in its accepted sense in biology, induction is the release of one phenomenon under the influence of another or of an external agent. Action that leads embryonic cells to form a structure that the inductor itself does not possess (see Organiser). Induction leads to the formation of a harmonious succession of organized structures. I, 98, 99; IV, 39.

Inductive properties: properties possessed by the organizer, or an inductive tissue, of determining the differentiation of an adjacent tissue that is as yet undifferentiated. I, 137.

Inductor: a vague word often employed to designate both organizer and evocator (Needham); it is generally understood to mean a fragment of living tissue that determines differentiations in tissues that are not yet differentiated. I, 146, 150, 151.

Industrial medicine: a branch of medicine that includes research into and the prevention of occupational diseases, as well as systematic examinations and early detection, hygiene, and factory legislation. VI, 66-71.

Infarction: a lesion of tissue caused by the obstruction of a vessel irrigating it. Myocardial infarction is a lesion of heart muscle due to the obstruction of a coronary artery. Lung infarction is caused by the embolism of a lung artery or one of its branches by a circulating clot; this is most often of phlebitic origin. Infarction may also be produced in other organs (intestinal infarction). VI, 83, 84, 85, 86; VII, 22, 23.

Inflammation: a physiological reaction to the penetration of pathogenic micro-organisms into the organism, particularly following a wound. Inflammation is characterized by local tumefaction and vasodilation accompanied by pain. VI, 30, 33; mi.

Influenza: this contagious disease is caused by a virus that attacks the cells that line the respiratory passages. Generally benign, influenza may develop in the form of an epidemic (eg, Spanish influenza in 1918). VI, 23, 29-31, 51.

Infundibular stenosis: a congenital narrowing of the lung infundibulum, responsible for dilatation of the right ventricle, quickly followed by right-sided heart insufficiency. VII, 119.

Infusoria: ciliated unicellular animals, the most common of which are paramecia, stentors, and vorticellae, representing a well-developed group: in the single cell a number of parts are differentiated which have different functions, such as a mouth orifice and a caudal orifice, as well as contractile fibrils which are precursors of the muscle fibres of multicellular organisms. I, 85, 103; mi.

Inhibitor: a chemical substance that plays a part in the life of plants, preventing seeds from germinating and buds from opening when conditions are unfavourable. Some inhibitors are simple substances and are well known (phenolic acids and coumarin). The identity of many of them, however, is not known. III, 88.

Injection booster: a term given to the 'booster' dose of certain vaccines. This injection is used when risks of infection are particularly serious, as in epidemics and wars. It follows the two injections that constitute normal vaccination. II, 133.

Inoculation: the introduction under the skin, by a scratch made on its surface, of a substance containing germs of a disease (pathogenic microbes or viruses). VII, 40.

Insect: any aerial arthropod that breathes by means of the tracheae, the body consisting of a head, a thorax, and an abdomen; the head carries a pair of antennae and the thorax three pairs of articulated limbs. II, 31, 32, 34, 37-48, 50, 52, 148-158; mi.

Insulin: a hormone secreted by the islets of Langerhans of the pancreas, which lowers the amount of glycaemia and of which the presence is essential in the use of glucosides by the tissues. IV, 125; V, 52; VI, 97, 104, 105-107; VII, 51.

Interference: a biological phenomenon by means of which the presence of a virus in a cell excludes the penetration of any other viral species in the same cell. Interference differs from immunity inasmuch as it is not specific; it is due to the presence in the cells of a special substance called interferon. IV, 21, 22; V, 107.

Interferon: a protein, of low molecular weight, present in small quantities in all animal cells and possessing the remarkable property of preventing virus multiplication. It 'interferes' with their reproduction, no doubt by means of a mechanism of enzyme competition. In a cell invaded by a virus, the amount of interferon suddenly increases and then after three or four days decreases; if the amount of interferon produced is sufficient to neutralize the virus, spontaneous recovery of the invaded cells occurs. Although it is of a protein nature, interferon is not an antigen and after inoculation into an organism, it does not produce any immunity reaction. However, it shows a certain specificity, only protecting an organism efficaciously against proliferation of viruses if it has been prepared with cells of an organism of the same animal species or of one closely related. In the case of human virus diseases, recent experiments, carried out on small-pox virus with samples of interferon from certain species of primates, appear to show the therapeutic efficacy of the substance, which perhaps in the near future will play a role such as that played by antibiotics in microbial diseases. IV, 22, 139, 140, 142; VI, 23.

Interoceptor: a sensory organ situated inside the organism that reacts to internal stimulations as opposed to exteroceptor sensory organs (such as the eye or the ear) that react to external stimuli. The nerve plexus situated in the intestinal wall and sensitive to distention or irritation, is an example of an interoceptor. II, 65.

Intersexual: an individual that commences its development with its own genetically determined sex and completes it in the opposite sex. I, 143.

Interstitial fluid: extracellular circulating fluid in the interstices of living matter in which all the cells of an organism are contained. This fluid, the chemical composition of which is remarkably constant, may, even more than blood and lymph, be considered as the true internal environment of the whole living organism. V, 24, 27, 41; VII, 26, 50.

Interstitial gland: all those cells, known as interstitial cells or Leydig cells, situated in the testis between the seminiferous tubules. These are the cells that produce male hormone, the spermatozoa being produced by the seminiferous tubules. I, 145, 146; VI, 103.

Inter-ventricular communication: the persistence of communication between the right and left ventricles of the heart after birth. This congenital malformation is rarely isolated (Roger's disease) and is more often associated with other malformations (trilogy and tetralogy of Fallot). VII, 120-122.

Intraventricular septum: the thick muscle wall that separates the two ventricles of the heart. VII, 121, 122.

Intestinal perforation: an opening resulting from an ulceration of the intestinal mucosa, especially near the appendix, caused by Eberth's bacillus (typhoid fever) and forming a small hollow wound shaped like a funnel. It requires urgent surgical operation. VI, 22.

Invasion phase: the time that elapses between the appearance of the first characteristic signs of a disease and the disease itself. VI, 22.

Iodine: an element, no. 53 in the periodic table; it is abundant in marine algae. Iodine is essential in the synthesis of hormones secreted by the thyroid gland, the main one being thyroxine. Almost all the iodine introduced into the organism is stocked in this gland. A deficit of iodine in food supply causes characteristic disturbances and thyroid insufficiency. The role of iodine in thyroid function has been clearly elucidated by the use of the radio-active iodine isotope. V, 27; VI, 14, 99, 102; VII, 15, 81, 94.

Iron (ferro)-bacteria: bacteria with the property of transforming insoluble iron compounds into soluble ones and using the energy derived from this transformation for their own metabolism. IV, 72.

Irradiation, localized: a technique that makes it possible to irradiate a sharply defined area by x-rays or ultraviolet rays. It is used in embryology to destroy certain cells selectively or certain parts of organs and to study the repercussions of their destruction on the further development of the embryo. Localized irradiation is also employed in cancer therapy to destroy the cells selectively without damaging the tissues in the healthy parts nearby (see also Cancer). I, 149, 150, 151; VII, 89, 95-99, 110.

Ischaemia: a local deficiency of blood, caused mainly by the contraction or obstruction of a vessel (myocardiac ischaemia after coronary thrombosis). VI, 83; VII, 104, 130.

Isogamy: in sexual reproduction of unicellular organisms, cases in which the two cells that unite appear very similar in aspect and size; the contrary to anisogamy. II, 49.

Isoniazid: a drug used in the treatment of tuberculosis in association with PAS and streptomycin. VI, 26, 27, 28; VII, 41, 86.

J

Jaundice: a yellow coloration of the skin, due to the presence of biliary pigments in the blood. Jaundice is a common symptom in numerous diseases, such as hepatitis, biliary lithiasis, hepatic insufficiency, and haemolytic jaundice. Haemolytic jaundice of the new-born (Minkowski's disease) is due to too great a fragility of the red cells. It is connected with a blood disease and the formation of excess biliary pigments. VI, 80, 82, 139, 140.

Jump conduction: transmission of nerve impulses by 'jumps'. In most of the nerves of vertebrates, the axis of the nerve, or axon, is surrounded by a sheath formed by a lipoprotein called myelin, with interruptions at regular intervals called 'Ranvier's nodes'. In these nodes the myeline covering plays the part of an electric insulator, and nerve impulses, instead of going from molecule to molecule, jump from one node to another. V, 64.

Juvenile hormone: a hormone secreted in insects by small cervical glands known as the 'corpora allata'. Its presence in the body of the insects leads to the conservation of larval character and the inhibition of metamorphosis. II, 45, 46.

K

Kala-azar: a disease caused by a protozoon (*Leishmania donovani*), transmitted to man by the bite of a dipterous insect, *Phlebotomus*. It is characterized by prolonged fever, anaemia, accompanied by a noticeable diminution in the number of leucocytes, and an increase in the size of the spleen. The disease is very widespread in India and the Far East. VI, 31.

Karyogamic rejuvenation: in *Paramecium*, genetic renewal by the exchange of nuclear material during the temporary fusion of two partners of different sex (conjugation). In a population of ciliated protozoa, such a nuclear modification is required to avoid ageing and degeneration after a number of simple divisions. I, 104-106.

Karyology: a field of biology concerned with the study of the nucleus of cells. III, 129, 131.

Keratin: see Keratotic differentiation.

Keratinization: the transformation of superficial layers of the skin or of mucosa that become infiltrated with keratin. (See Keratotic differentiation). V, 57, 58; VII, 30, 96, 97.

Keratotic differentiation: a form of development of the epidermis. This is constituted by cell strata that are modified from below towards the surface and lead to the formation of non-nucleated lipidic scales, known as keratin scales. This differentiation may be observed in inner linings during pathological processes; it is the substratum of leucoplasias of the lingual mucosa, for example. If observed in a tumour of unknown origin, it indicates the epidermic nature (or potential) of the tissue concerned. VII, 30.

Kidney: an organ situated in the abdominal cavity that excretes urine. The interior of the kidney is hollowed with cavities (calices) communicating with each other in the renal pelvis. The fundamental unit of the kidney from the functional point of view is the nephron. In man, the kidney is 12 cm long, 2 cm wide and 2 or 3 cm thick. V, 21-24, 25, 26; VI, 93-95; VII, 14, 26, 51, 104; mi.

Kidney, pelvis: see Renal pelvis.

Kinaesiotherapy: treatment which acts on the body by subjecting it either to active or passive exercises (gymnastic or massage). VI, 38.

Kinetin: a plant hormone which appears to sensitize the plant to the action of auxin. I, 72; III, 16, 43, 87.

Kinins: a group of plant hormones that act on cell division. Kinins are derivatives of purine bases; they act especially on the development of buds and on the germination of some seeds. The best known is kinetin (6-furfuryl-amino-purine). III, 16, 39, 86, 87, 88.

Koch's bacillus: see Tuberculosis.

Koch's method: also called seeding, which consists in making successive dilutions of a pathological product in a liquid medium, and then depositing a few drops of the dilutions in tubes of previously melted gelose-peptone maintained at 50°C, which is then poured into Petri dishes. IV, 60, 62.

Koch's phenomenon: a very well-known phenomenon in immunology, discovered by the German, Robert Koch. When guinea-pigs that have been injected with tuberculosis bacilli, receive a second inoculation, they eliminate the new germs with great rapidity (with the local appearance of a necrosis). At the same time, this phenomenon also shows a defence reaction and a hypersensitivity reaction (allergy). IV, 138.

Krebs' cycle: a complex metabolic cycle that plays an essential role in cell respiration. In this process a molecule of pyruvic acid (produced by the splitting of glucose) is broken down into its constituent elements, carbon dioxide and oxygen. Krebs' cycle requires the intervention of three vitamins (B_1, pantothenic acid and PP). I, 41, 42, 43; VI, 106.

Krummholz: a type of irregular bush vegetation stunted by cold winds, in which resinous forms predominate, reaching the size of trees at lower altitudes and latitudes. III, 24.

Kwashiokor: a disease of tropical Africa (also called tropical cirrhosis) that appears in infants at the moment of weaning. It is characterized by digestive disturbances, loss of weight, oedema and anaemia, hepatomegaly and characteristic cutaneous lesions that leave scars; it is apparently due to a deficiency of animal protein. VI, 15, 109, 110.

L

Labenzyme (rennet): an enzyme present in the fourth stomach of young ruminants, causing clotting of milk. II, 58.

Lactic acid: an acid formed as a result of contraction in muscle effort where it accumulates. It is from lactic acid that aerobic resynthesis of glucosides is carried out in muscle. V, 127, 146, 147; VI, 62.

Lactose: a disaccharide formed by the combination of a molecule of galactose and a molecule of glucose. VII, 84.

Lagena: a foraminiferan protozoon possessing a bottle-shaped shell that includes a single cavity and a small aperture. It is a panchronic, or living fossil, animal. II, 25, 26.

Langerhans, islets of: see Pancreas.

Larynx: an organ composed of muscle, cartilage, and bone. It is richly innervated: situated in the upper part of the tracheal artery, it is concerned with the production of sound in mammals and in some other vertebrates. In reptiles and birds the larynx does not produce sounds; birds have a different vocal organ, the syrinx. V, 133; VII, 21; mi.

Lateral line: in fish, a term that designates a longitudinal tube starting from the head and ending in the tail along the sides of the fish. It is provided with a series of sense organs, which enable it to respond by escaping movements when agitation of the water exerts pressure against the sides of the body. II, 68, 69.

Laterization, or leaching: decomposition of granite under the effect of acid substances of humus and heavy rainfall. This phenomenon, which is produced especially in tropical regions, leads to the formation of laterite, a red clay that is unsuitable for cultivation. III, 122, 123.

Leaf spiral (foliar helix): spirals along which leaves develop on the stem. Foliar helices originate in the generating centre of the initial ring. III, 62; mi.

Lecithical (egg): an egg that has vitelline reserves that are relatively abundant, tending to accumulate towards the vegetative pole. The eggs of molluscs, annelids and amphibians (frogs) are lecithoblasts. They undergo total but unequal segmentation or cleavage. I, 128, 130; mi.

Leishmania: flagellates in the blood circulation causing cutaneous Leishmaniasis and Kala-azar. The vector of this disease is *Phlebotomus*, a small blood-sucking dipteran. VII, 34, 75.

Leishmaniasis: see Kala-azar.

Lepisma: an insect about half an inch long, commonly called 'silver fish', which can be found in old books and papers. The Lepismidae form part of the Apterygotea, a sub-class of wingless insect; they are blind and very primitive. Unlike other insects, the Lepismidae become sexually mature before becoming fully grown; they are specimens of panchronic or living fossil insects. II, 43.

Leprosy: a highly contagious disease caused by Hensen's bacillus, endemic in tropical countries. Leprosy causes deformations of the face and extremities. VII, 141.

Leptotene: a stage of meiosis (prophase) during which thin unwound chromosomes become visible. It is the beginning of meiosis. I, 117.

Lethal effects: the effects of radiation that prevent the proliferation of cells (probably by affecting the chromosomes of the nucleus). VII, 96.

Leucoblasts: the youngest elements of the leucocyte series, which are found in great number in the blood of patients with acute leukaemia. Their presence in the blood is abnormal. VII, 31.

Leucocyte: see White blood cell.

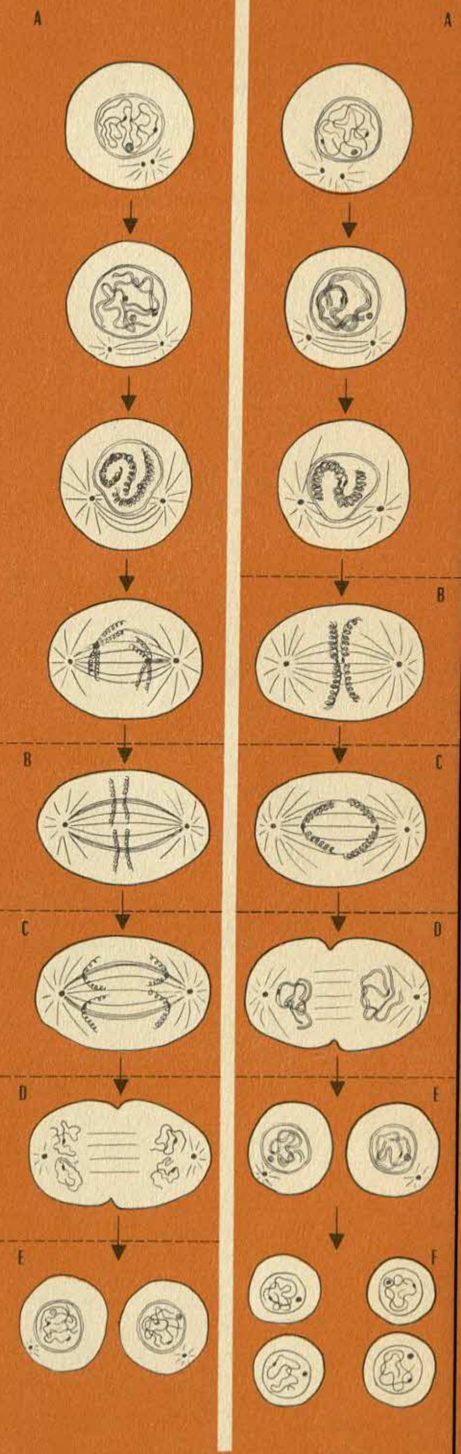
Leuconostoc mesenteroides: a bacterium used in industry for the production of dextrans, a substitute for blood plasma. IV, 15.

Leucopenia: a diminution in the number of white blood cells normally contained in the circulation (on average, 6,000 per cubic mm). IV, 28, 29; VII, 31.

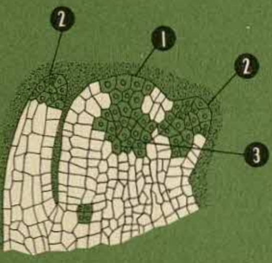
Leucoplasia: a chronic affection of the mucosa of the stratified pavement epithelium (the mucosa of the mouth) and, more rarely, the mucosa of the vulva, the vagina, and the bladder. This disorder is characterized anatomically by transformation of the superficial part of the epithelium and clinically by white or opaline spots. It sometimes turns into cancer. VII, 30.

Leucoses: leukaemic conditions, ie, acute or chronic disorders characterized by proliferation from the centres that form leucocytes and manifesting themselves by invasion of the blood by white cells or by their rarefaction, when pathological proliferation destroys the bone marrow. The diagnosis of these particular leukaemias can only be ascertained by sternal puncture. VII, 30, 31, 34.

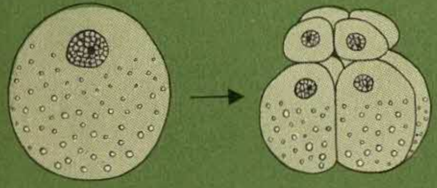
Leucotomy: a surgical operation that consists of cutting part of the white matter of the frontal lobe of the brain. VII, 138.



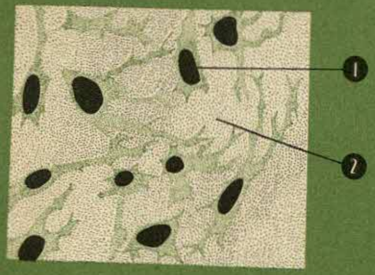
Meiosis
Mitosis (left). meiosis (right). A. Prophase. B. Metaphase. C. Anaphase. D. Telophase. E. Young cells (daughter cells). F. End of the second meiotic division.



Meristeme
1. Initial superficial cells. 2. Leaf bud. 3. Initial internal cells.



Meroblastic (eggs)



Mesenchyme (Vertebrate embryo)
1. Mesenchyme cells. 2. Ground substance (matrix).

Leukaemia: a disease characterized by an excessive and anarchic functioning of the organs that form white cells. Leukaemias are probably related to cancer. The disorder is always fatal, but with varying delays, sometimes in a few months, sometimes in a few years, according to the type of leukaemic proliferation in the blood. IV, 101-103; VI, 113, 131-135, 147; VII, 31, 34, 78, 98-101.

Leydig cell: see Interstitial gland.

L forms: particular forms of bacteria consisting of small granules. The L form may appear naturally from normal forms or may be produced by the intervention of physical or chemical agents, such as antibiotics, x-rays, etc. IV, 22, 41.

Life cycle: a regular succession of various stages, or phases undergone by an organism during the course of its existence and finishing with the return to the first stage or initial phase. I, 105; III, 56-58.

Lignin: a chemical substance that impregnates wood and gives it its characteristic consistency. III, 148.

Limulus: a living fossil of the Arthropod group: Limulus has the appearance of a trilobite. It lives in hollows on the shores of shallow warm seas and eats anemones or starfish. It may reach a length of two feet. II, 26, 28; mi.

Lipids: constituents of fats. Their molecule results from a combination of an alcohol and a fatty acid with four carbon atoms at least, with elimination of a water molecule. The principal types of alcohols entering into their composition are the glycerols and the sterols, which give ternary lipids, that is to say, including only carbon and oxygen. There are more complex lipids, which, for example, liberate by hydrolysis fatty acids and alcohol, together with phosphoric acid. These lipids are soluble to differing extents; organic solvents that will dissolve them are alcohols, ether, acetone, and benzol; they are only very slightly soluble in water. They are one of the three large categories of organic substances making up protoplasm (on average, they supply 11·7% of living animal matter); the other two categories are glucosides and proteins. I, 37, 38, 39; IV, 46, 47, 51, 52, 81.

Lipocytic coefficient: the concentration of fat held by a cell. V, 43.

Lipogenesis: formation of organic fatty substances in animal and plant organisms out of foodstuffs. I, 90.

Lipoprotein: a complex lipid to the molecule of which is added nitrogen, phosphorus or sulphur. Lipoproteins constitute an important part of the cell membrane and are essential constituents of the grey and white matter of the brain. To this group belong myelin of the nerves and lecithin of egg yolk. I, 152, 153.

Lithiasis: see Calculi.

Liver fluke: a trematode hermaphrodite worm that is a parasite in the bile duct of herbivores and man. It gives rise to jaundice and to lesions of the walls of the bile duct, also to formation of biliary calculi, and finally to a cirrhosis of the liver. VI, 40; mi.

Lobar pneumonia: a disease caused by a pneumococcus, characterized by acute inflammation of the lung, of which it attacks a complete lobe, and characterized also by the presence of an exudate of a fibrous nature that fills the lung alveoli. VI, 22.

Lobe, brain: part of the cerebral hemisphere delimited by clefts or fissures. In man, there are the frontal, parietal, temporal and occipital lobes. V, 60, 77, 87.

Lobectomy: removal of a lung lobe. VII, 110.

Locus: the place on a chromosome where any given gene or one of its alleles is sited. I, 122, 124.

Locus niger: the nucleus of the mesencephalon or middle brain. V, 68.

Locust: an orthopterous insect of the Acridia family that lives in warm, dry regions. Locusts do not undergo metamorphosis, but reach adult form by a series of successive moults. Migratory locusts, gregarious insects living and moving about in immense swarms, constitute one of the main dangers of cultivation in Mediterranean countries. The locust is of particular interest to the biologist because it is excellent laboratory material for studying the development and conditions of shedding and the social behaviour of insects. II, 38-41, 45, 48, 109.

Locusta migratoria: see Locust. I, 115, 116.

Lomechusa: a coleopterous insect parasitic on ants which, once it penetrates into an ant hill, rapidly disorganizes it owing to a curious phenomenon of 'social perversion'. The larvae of *Lomechusa* are brought up by the ants and because of this they neglect their own larvae. *Lomechusa* adults secrete a fluid on certain hairs of their abdomen (trichoma), which is very attractive to the ants and intoxicates them, making them lose all social sense. II, 118.

Lung capacity: the total air capacity of the lung. It is the sum of the vital capacity (4 litres) and residual volume of air (1·2 litres). V, 14.

Lupin: a fodder plant of the *Papilionaceae* family with pink or white flowers. III, 63.

Lupus erythematosus: a form of dermatosis characterized by red spots limited in area and covered by adherent scales, disseminated on the face, the ears, the back and the hands; it is a benign disorder when found by itself. Sometimes two such cutaneous lesions are associated with general manifestations affecting the kidneys, joints, the heart and breathing; this is malignant lupus erythematosus, which is fatal within a few months. VII, 66.

Lutein: see Progesterone.

Luzulus: a monocotyledon plant of the Joncacea family, very common in damp soil. III, 65.

Lycin: a variety of antibodies that have the property of dissolving bacteria (with the aid of complement). VI, 43.

Lymph node: a nodule of lymphatic tissue, the size of a pea, on the path of a lymph vessel. The lymph nodes, numbering four to six hundred in man, are formed by a connective tissue capsule filled with lymphocytes. In cases of bacterial infection, the bacteria are stopped in the nodes in which they are destroyed by the lymphocytes. The lymph nodes play an important role in the defence of the organism against infections. VII, 29, 98.

Lymphoblasts: stock-cells that are still undifferentiated and that form lymphocytes. IV, 102; VII, 34, 98.

Lymphocytes: white cells with a rounded nucleus, representing 20% to 25% of the total white blood cells. (The other two categories of white cells are granulocytes or polymorphonuclear cells with a polylobular nucleus, and monocytes with an oval or incurved nucleus). V, 28, 31; VII, 34, 53, 98, 99, 101.

Lymphocytosis: absolute or relative increase of the number of lymphocytes in the blood. VII, 31, 101.

Lymphogranulomatosis: a disease affecting the lymph nodes; often a synonym of Hodgkin's disease (q.v.). VII, 34, 90.

Lymphosarcoma: a malignant tumour defined by the three following characteristics: (1) it is formed of neoplastic cells belonging to the lymphoid series; (2) these cells invade and infiltrate the node capsule and nearby tissues; (3) proliferation does not usually affect more than one cell-form. The aspect of lymphosarcoma tissue is monomorphous. V, 139.

Lyophilization (or freeze-drying): a method of drying a substance that has been previously frozen. It makes possible the preservation, without any marked deterioration, of numerous biological products. IV, 97; V, 33.

Lysis: the destruction of certain microbes (eg, the cholera vibrio) by the combined effect of an antibody and a substance present in nearly all normal sera: complement. The antibody and then complement become fixed on the microbial body. This then begins to 'melt' like wax. IV, 107, 110, 120.

Lysogenization: a property possessed by certain bacteria (lysogenous bacteria) of resisting the attack of 'temperate' bacteriophages and, under certain conditions, disseminating these same bacteriophages into the environment. IV, 19, 107.

Lysozyme: an enzyme of low molecular weight, discovered by A. Fleming in 1922. It is present in fluids of the organism (tears and nasal mucosa) and has the property of lysing bacteria and attacking the mucopolysaccharides of the bacterial membrane. IV, 121.

Lytic cycle (or infectious cycle): in virology, a phenomenon leading to active production of bacterial viruses (or bacteriophages) and ending in lysis, ie, the destruction of corresponding bacteria. II, 107.

M

Macrocyte: a pathological red cell (q.v.) with an unusually large diameter. VI, 79; VII, 31, 101.

Macrocytosis: the presence in the blood of macrocytes or red cells with a diameter of 8 to 9 microns (the normal diameter of a red cell is 7 microns). Their identification makes it possible to define the characteristics of some anaemias. VII, 31, 101.

Macrolids: natural organic compounds occupying an intermediate position between sugars and fatty acids. Macrolids have a large lactone ring (consisting of a chain of 11 to 17 carbon atoms) to which are attached sugars of a novel form, some containing nitrogen. A large number of macrolids have been isolated in the form of crystals and their structure has been determined. Among those that have been used clinically, are erythromycin, carbomycin, oleandomycin and spiramycin. Macrolids are effective against Gram-positive bacteria. They are little soluble in water, and do not diffuse very well. VII, 87.

Macrophage: a white cell or mononuclear leucocyte having the property of phagocytosis, important in the defence of the organism against microbes. The macrophage is a particular type of monocyte. I, 64, 66, 67; IV, 113, 123; VI, 22, 43.

Macrosmatic animals: vertebrates with a highly developed sense of smell. V, 87.

Macula: a depression of the retina, also called yellow spot, situated at the posterior pole of the eye. It is the point of clearest vision. VI, 141.

Malaria: an infectious disease characterized by attacks of fever, in some cases occurring at regular intervals. It is due to a protozoon, a parasite of the red cells of the blood, called *Plasmodium*, which is inoculated by a mosquito bite in warm and swampy regions. The mosquito is *Anopheles*. VI, 23, 42, 43, 45-47, 71; VII, 74, 75.

Malaria crisis, malignant: this is accompanied by neurological manifestations caused by *Plasmodium falciparum*, requiring anti-shock treatment and prompt anti-malarial treatment. VI, 43.

Malariotherapy: treatment of syphilis of the nervous system by means of an artificially induced malarial infection. IV, 125, 126.

Mammal: a class of vertebrates showing the following characters: the presence of hair, a heart with four cavities, metanephric kidneys, and a well-developed brain. They are viviparous (except Monotremes) and suckle their young by secretions of milk from their breasts. They are homeothermal. II, 15, 20.

Mangrove: a variety of forest on the beaches of semi-tropical countries, especially on lagoon coasts, that is to say, those that are exposed to the ebb and flow of the tides. III, 121, 122.

Measles: an infectious disease, caused by a virus, characterized by an eruption of small flat red spots, separated by intervals of healthy skin. Eruption round the nose is preceded by an intense catarrh of the oculo-nasal mucosa, and the occurrence of whitish punctiform spots surrounded by a red aureole on the internal side of the cheeks. VI, 19, 22, 23, 51.

Mediastinum: a space between the lungs where the heart, the large vessels, the trachea and the oesophagus are situated. VII, 22.

Medulla, adrenal: see Adrenal.

Medulla oblongata: part of the brain, situated immediately in front of the spinal cord. It is from the medulla that numerous cranial nerves take origin, including those of the sympathetic and parasympathetic systems, hence the importance of the medulla for visceral functions. It also contains a number of regulatory centres, such as the respiratory centre and the muscle-tone centre. VI, 87.

Megakaryocytes: large cells (50 to 100 microns) found in bone marrow. Megakaryocytes give rise to platelets. VII, 31.

Megalocornea: an enlarged cornea; a recessive sex-linked hereditary characteristic. The diameter of the cornea may reach 16 mm, although the eye continues to function, and ocular pressure is normal. VI, 142.

Meiosis: see Cell division.

Melanin: black pigments secreted by chromatophores. Melanocytes and melanophores are found in the nervous tissue or neuroglia (q.v.).

Melanodermia: a symptom characteristic of various diseases (Addison's disease, q.v.) consisting of a dark skin pigmentation. V, 52, 54.

Melanoma: the generic name of melanic tumours. (1) The benign melanoma or naevus is a congenital disorder that develops very slowly; it causes a limited deterioration of the colour and texture of the skin and exists in a number of varieties, eg, pigmentary, tuberous and adenomatous melanoma. (2) Malignant melanoma is a cutaneous tumour, often pigmented, that develops in the cell naevi; this disorder is highly malignant. VII, 96.

Memory: 'Preservation of the past by a living being within his organism' (from Lalande's *Vocabulaire philosophique*). Memory, taken in its widest sense, is the lasting effect left in an organism by a past sensory experience. It is a fundamental property of living matter, derived from general awareness. This property, which exists even in the simplest unicellular organisms, like amoeba or paramecium, has imposed itself, in the course of the evolution of living beings, with or by a progressive differentiation of a specialized organ, the brain. This stores information coming from the external world and reaches its culminating point with the appearance of the human species. It is generally admitted that memorization, the remembrance of any particular event, implies a specific reorganization of associations within neurones; this hypothesis leads us to suppose that the initial activation of synapses by sensory impulses causes a change, a facilitation that increases the efficacy of those synapses. In simply organized animals, the nerve network is little centralized, and the storing of information is not very efficient; it is a slow process that implies an apprenticeship of greater or lesser degree and conditioning; eg, a group of paramecia accustomed to swimming along the side of an aquarium of given dimensions, will continue for some time to make the tour of an imaginary tank of the same dimensions when they are transported into a larger tank. The animal must decondition itself before being able to memorize new sensory impressions. The memory of a human being, on the other hand, is enormous. The Swedish neurophysiologist, Holger Hyden, has estimated that during the course of a human being's existence, his brain can store a thousand million million elements of information (10^{15}). Hyden has recently suggested a cytological basis for the phenomenon of memory, according to which the material basis of memory is ribonucleic acid (RNA) of the nerve cells. The information transmitted to these cells by sense organs can be codified by RNA molecules, just as genetic messages are codified and transmitted to daughter cells by DNA. Since the nerve cells, once they have differentiated, do not multiply in a given individual, after the regular physiological renewal of protein molecules of the cell, the new molecules of RNA are only copies of the old ones; the code therefore is not modified and memory does not alter, unless RNA is destroyed. V, 70, 78, 79, 88, 121, 138.

Mendel's laws: the fundamental laws of the transmission of hereditary characters, set out by G. Mendel in 1865. These laws constitute the basis of studies on heredity. I, 116, 118, 119; II, 44; III, 129, 130; V, 38, 39, 40.

Meningitis: all acute or chronic inflammations of the cerebral or medullary meninges (caused by viral infections or poisoning). A large number of meningites are caused by the meningococcus (cerebrospinal meningitis); others are caused by pyogens (streptococcal meningitis). Tuberculous meningitis can still be fatal despite modern anti-tuberculous compounds. Again, there may be lymphocytary meningitis caused by viruses (mumps, poliomyelitis, etc.). All these forms of meningitis have a common characteristic: fever, meningeal symptoms (stiffness of the neck, headaches and constipation), psychological disturbances and vasomotor upsets. VI, 27, 37; VII, 34, 86.

Meningococcus: a diplococcal bacterium which causes cerebro-spinal meningitis. IV, 58; VII, 82, 85.

Menopause: final cessation of the menstrual function. It corresponds to the cessation of ovarian activity and is accompanied by a regression of secondary sexual characters with the appearance of sudden flushing and occasionally physical, neurological and endocrine disturbance. V, 137; VII, 35.

Meristem: a group of cells that have preserved their embryonic characters, that is to say, they are undifferentiated, or only slightly differentiated. III, 13, 62, 63.

Merotomy: surgical fragmentation of the cell; an experiment that aims to show the role of the nucleus (this can be done with amoeba). I, 106.

Mesenchyme: embryonic tissue that takes its origin from the mesoderm (q.v.) layer. These cells, often fusiform or stellate, are separated from each other by an intercellular space and linked by protoplasmic bridges constituting a supporting tissue in the embryo. During the course of development, the mesenchyme takes part in the formation of numerous organs and differentiates, in particular, into bone, cartilage, muscle and connective tissue. I, 139; mi.

Mesentery, intestinal: a membranous fold of epithelium in the coelom supporting the intestine. I, 146, 145.

Mesoderm: embryonic layer that originates in the marginal region of the egg. During gastrulation it moves until it lies between the ectoderm and endoderm. The layer develops into the muscles and the connective tissue of the embryo. Presumptive mesoderm is the marginal region of the egg, destined to form the mesoderm. This was discovered by the method of marking the egg with different colours. I, 133, 134, 139-142; VII, 29.

Mesonephros: the last stage of the differentiation of the embryonic kidney in fish and amphibians. In these animals, the mesonephros constitutes the functional kidney of the adult. In amniotes (reptiles, birds, mammals), the mesonephros is the functional kidney of the embryo. In the adult it is replaced by the metanephros. I, 144, 145, 146; mi.

Messor: a type of harvesting ant that stores seeds. Some of these seeds will germinate at random on the edges of the ants' nest, but such ants do not practise cultivation, as has been asserted. II, 115.

Metabolism: all the chemical changes that form the basis of living matter and the exchanges of energy that accompany these transformations. Metabolism includes two inverse and concomitant phenomena: (1) anabolism: this includes the constructive and repair functions of living matter and the synthesis of reserve substances. The first stage of anabolism is the assimilation of carbon by photosynthesis or chemosynthesis and requires large quantities of energy. (2) Catabolism: this consists of a number of degradations of substances and liberation of energy. The final phase of carbohydrate catabolism is oxidation of glucose into carbon dioxide and water: the molecules engaged in the process of metabolism are called metabolites; the principal categories of metabolites are glucosides, lipids and proteins. Between the initial phase of anabolism and the final phase of catabolism there are innumerable reactions: for example, transformation of metabolites into others, periodic renewal of protein substances.

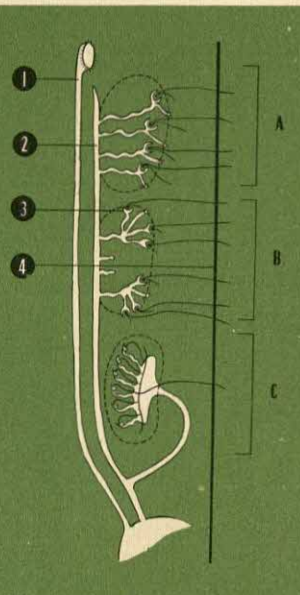
All these reactions are facilitated and activated by biological catalysts, enzymes. The intensity of metabolism depends on a certain number of factors: hyperthermy (fever) or an intense muscle effort that will increase it; hypothermy, on the other hand, will diminish it. This is what happens in natural hibernation and this property is nowadays used in surgery for operations in conditions of artificial cooling. In higher organisms (vertebrates) the intensity of metabolism is controlled by the thyroid; in general, in a state of complete repose, it is weak: this is called basal metabolism, which is measured by means of a spirometer and constitutes a means of investigation in pathology, since appreciable variations in the normal value of basal metabolism can be an indication of serious disturbances. I, 39; II, 60, 64, 110; III, 27-29; IV, 18, 73, 107, 110; V, 52, 72, 135; VII, 14, 62, 91.

Metabolite: any organic molecule engaged in the process of metabolism (lipids, proteins, glucosides, etc.). VII, 83.

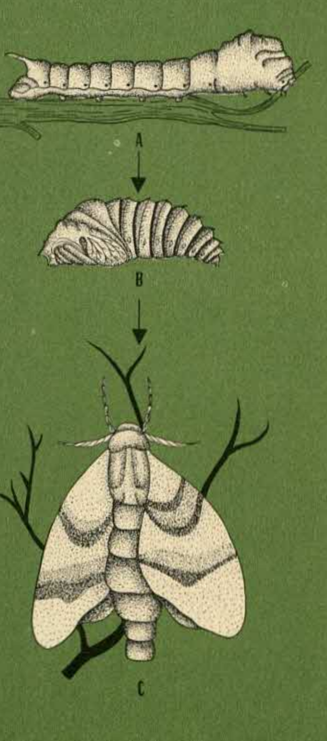
Metalloproteins: proteins containing one or more metallic atoms in their molecule. Such are the transporters of oxygen in the blood: haemoglobin (red pigment of the red cells of vertebrates, containing iron) and haemocyanin (which is found in the blood plasma of the lobster, Limulus, and a number of molluscs, which contain copper). There are also peptidases that contain manganese, flavoproteins that contain molybdenum, and others that contain iron. I, 152, 153.

Metameric segmentation: division of the animal organism into successive segments along the main axis of the body. Each metamere corresponds to a section of the coelom. In certain invertebrates, such as the annelids and the myriapods, this segmentation is very marked externally. However, in the majority of animals it is only shown obscurely (metamerization of the vertebral column, regular succession of the sympathetic ganglia). II, 17.

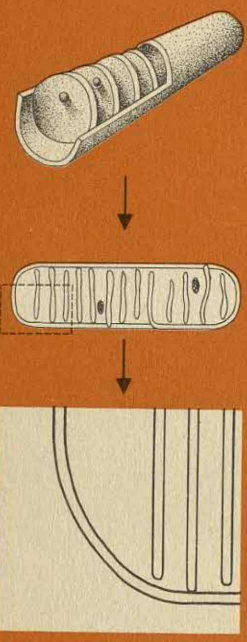
Metamorphosis: a striking and sudden change of form which a number of animals undergo at the beginning of their life as



Mesonephros
A. Pronephric or primitive kidney. B. Mesonephric or intermediate kidney. C. Melanephric kidney. 1. Mullerian duct. 2. Wolffian duct. 3. Glomerulus. 4. Aorta.



Metamorphosis (*Bombyx mori*)
A. Caterpillar. B. Chrysalis. C. Imago (adult).



Mitochondrion

adults. Metamorphosis results from indirect development; the young larval form is transistory and sometimes differs so much from the adult that it is difficult to identify the species to which it belongs without having followed the development of the successive stages. In considering metamorphosis, one usually thinks of insects; their two or three successive forms (larva, nymph and imago) appear to characterize the very notion of metamorphosis. Certain insects, of which the larval forms approach the adult form, only show incomplete metamorphosis; such are, for example, crickets or cockroaches. In others, such as butterflies or bees, the passage from the larval form to the imago involves immobilization inside a rigid covering (nymphal form or chrysalis): this is complete metamorphosis. There are other animal groups, vertebrates and invertebrates, that undergo metamorphosis: for example, sea urchins with their pentagonal radial symmetry, the larva of which possesses a bilateral symmetry; frogs which develop as tadpoles; and eels, the larvae of which are leptocephali in the Sargasso Sea. Metamorphosis is under hormonal control; in insects, it is a hormone secreted by the prothoracic glands, which is called the moult hormone or ecdysone. Its experimental injection into an insect in the larval stage immediately causes a moult, or metamorphosis (according to the insect and the stage experimented on). In vertebrates the hormone of metamorphosis is thyroxine secreted by the thyroid gland: a tadpole without a thyroid never changes into a frog. The precise significance of metamorphosis is still unknown, but it is clear that this process of development is an old inheritance: the same genes control the successive appearance of a larval form, a nymph form and an adult form; it appears logical to compare metamorphosis with polymorphism (q.v.) and in particular with sexual dimorphism (q.v.). I, 129, 133, 134, 156; II, 38, 42-47; mi.

Metanephros: the last stage in the differentiation of the embryonic kidney in reptiles, birds and mammals. Also, the functional kidney of these animals. II, 20.

Metaphase: the second stage of mitosis; the chromosomes, placed at an equal distance from the two poles, form the equatorial plate; they then appear to be split longitudinally. I, 62, 63, 64.

Metaphytes: plants composed of many cells (q.v.).

Metaplasia: the transformation of a differentiated cell into a cell of another type. I, 73, 74; VII, 30.

Metastasis: a secondary cancerous formation. Cancerous cells are capable of leaving their initial location and entering the blood vessels. In this way they are transported to varied points in the organism. There they multiply anarchically, as in the initial location, and create metastases, or new cancerous nodules. I, 83, 84; VI, 121; VII, 28, 89, 94, 105, 110.

Metazoa: multicellular animals in which numerous differentiated cells in the tissues are grouped in functional systems or in organs. II, 16, 17; IV, 112, 113.

MEVS: abbreviation of maximal expiratory volume per second. The MEVS is determined by making a forced expiration, after a maximal inspiration as rapidly and as completely as possible. Recording is carried out by means of a rotating cylinder. VII, 24.

Micelle: the aggregate of macromolecules forming a colloidal (q.v.) solution.

Microaerophil: something that can only live under reduced oxygen pressure. IV, 58.

Microbe (or micro-organism): any living being of very small size that cannot be seen except under a microscope. Such are bacteria, viruses, microscopic fungi, and protista. This word is not synonymous with bacterium. III, 72; IV, 11, 12, 37, 51, 144-147.

Microcinematography: the use of microscopy with ordinary light and a dark ground, and with phase contrast or phase difference, etc., to study over a period of time, the behaviour of living cells or of some of their constituents. By taking pictures at normal, accelerated, or reduced speeds, this technique has made it possible to investigate problems of cell biology; it is particularly useful when it is completed by analysis of the films, still by still, by precise methods. I, 60, 63.

Microclimate: the climate in a restricted area in relation to the general climate of a geographical region. II, 110.

Microcytosis: an anaemia characterized by the presence of microcytes in the blood. These are red cells, the diameter of which is approximately 6 microns instead of 7 microns (the diameter of normal red cells). VII, 31.

Micromanipulator: an apparatus allowing delicate manipulations to be made under the microscope: eg, the seizure of an isolated germ, dissection, excision of part of a microbe, etc. IV, 49, 107, 110.

Microphages: phagocyte cells belonging essentially to a group of polymorphonuclear neutrophil cells which are normally found in the blood and in focuses of suppuration. I, 86.

Micropyle: an orifice of the ovule of plants. III, 77, 79.

Microscopical observation: this general designation includes all methods and techniques by means of which it is possible to study cells and tissues. Microscopical observation includes, on one hand, the techniques of preparation of cells, and on the other, the various optical methods whereby the elements that constitute the cells are rendered visible. Histology (study of tissues) and cytology (study of cells) may be applied both to living cells and to prepared cells on slides or cut into very thin sections. In both cases, the appropriate stains show certain parts of the cell in a differential fashion, and make up for the lack of refraction and for the transparency of the hyaline gel of the protoplasm and thus facilitate observation. Pigments or stains for living cells are not very numerous (neutral red and Janus green). On the other hand, for fixed cells there are a great number of basic stains which have several variants: there are routine stains (eosin and haematoxylin) used especially for histological purposes, and special stains used for showing up in selective fashion certain cell elements: such are the Feulgen stains for DNA of the nucleus, the Pappenheim stain for differentiating the basophil granules of the red cells, the special Golgi stains for nerve fibres, the silver stain for the ciliary networks of paramecia, etc. On sections of cells it is also possible to use certain cytophysical methods, such as micro-incineration, which only leaves the mineral outline of the cell, and spectrography with x-rays. Ultracentrifugation enables us to isolate the morphological constituents of the cell differentially. Microdissection enables us to suppress or add certain cell elements. Direct observation of cells is made by means of different kinds of microscopes: the first is the optical or photon microscope, which permits the observation of objects with a size of at least a quarter of a micron. For smaller cell elements (eg, mitochondria or microsomes) or for the study of viruses or bacteriophages, the electron microscope is used, in which the resolving power is ten to 100 times greater' than that of the ordinary microscope. Other microscopes are used to obtain special results: the polarized light microscope gives indications on molecular arrangement of cytoplasm or of certain cell reserves (grains of starch); the dark ground microscope allows only diffracted light to pass; finally the phase-contrast microscope, by accentuating the differences of refraction of the various cell elements, allows the observation of living cells that are not coloured. I, 29-34; VII, 29-35.

Microsome: particles in the cell (5 to 300 millimicrons in size), rich in ribonucleic acid fixed on ergastoplasm and serving as a template for protein synthesis. I, 53, 54.

Microtome: an instrument used for obtaining very fine sections of tissue for examination under the microscope. VII, 29.

Microvilli: tiny cytoplasmic prolongations that line the free margin of some ciliated epithelial cells. One of the best-known examples is that of the microvillosities of the intestinal mucosa ('brush-like' border). The innumerable lined loops thus formed have a functional significance of great importance, since they increase the surface of the cell membranes and facilitate the absorption by the cell of liquid or solid food particles (pinocytosis). I, 46, 47, 48; II, 73.

Migration: journeys in groups undertaken by certain animal species, sometimes to great distances. The migrating group is usually very large, for example, the flights of butterflies or migrating locusts number several million. These journeys may include a regular outward and return trip, with a seasonal or annual cycle; or they may be irregular and only take place in one direction: it is then usual to speak of an exodus.

This form of migration without any reason or aim is best illustrated by the excursions of lemmings, small Scandinavian rodents, or the migrations of locusts. The term migration is usually reserved nowadays for a regular outward and return journey. In this category there are bird migrations, salmon and eel migrations, and those of certain butterflies, in which one generation goes out and the next comes back. The determinism of these migrations is more or less well known; it appears that the migratory impulse is of physiological origin: the role of endocrine glands, in particular the pituitary and the sexual glands, in vertebrates is undeniable. On the other hand, ideas about the processes that direct migrations and allow an animal group on the move not to lose its direction and to return regularly to the chosen point are more speculative. The most recent theory in the case of birds is astronomical orientation, by day in relation to the sun, by night in relation to the stars. In the case of salmon and eels, there are variations in the functioning of the thyroid that trigger off these periodic voyages. The determinism of irregular migrations is more obscure. Neither hunger nor thirst, nor a desire to escape from unfavourable climatic conditions are the cause. But it has been shown in the case of locusts, interactions between external, sometimes unpredictable factors (climatic variations, in particular) determine the assembly of a large number. These factors, associated with morphological and physiological changes, such as the passage from the larval form to the imago, linked no doubt with what may be called the group effect, excite the migratory instinct of these animals. But the case of lemmings is far from being elucidated. II, 109–112.

Mildew: a microscopic parasitic fungus of certain plants. The mildew of the vine *(Plasmopora viticola)* came from the United States, where in the past it has caused serious damage. Mildew may also be parasitic on potatoes and tobacco. III, 68.

Mimicry: a resemblance of certain living beings to other species. Mimicry is called Mullerian when an unpalatable species mimics another unpalatable species and they share the losses involved in the education of predators; it is called Batesian when a palatable species imitates another that is not edible or is harmful to its predators. II, 124, 125, 126.

Mineralcorticoid: see Adrenal cortex.

Mitochondria: the elongated or rounded bodies of cell cytoplasm, which have been shown in all cells, except blue algae (Cyanophyceae) and bacteria. Mitochondria have a very complex structure: inside a double membrane, formed by two layers, are to be found the lamellae or crests (which are perhaps the prolongations of the internal layer) and a central substance enclosing some easily stainable granule, of unknown nature. Mitochondria contain most of the enzymes of cell respiration; they thus constitute the source of energy of the whole cell. Synonym, chondriosome. I, 43, 58, 60, 61; II, 59, 62; III, 16; V, 34, 46; mi.

Mitosis: see Cell division.

Mitotic poisons: chemical agents that inhibit mitosis by acting on the stages of this process; for example, colchicin blocks mitosis at the metaphase stage. I, 64, 65.

Mitral stenosis: a disorder that is most often due to a rheumatic infection (acute rheumatic fever) consisting in the progressive closure of the mitral ring that joins the left auricle to the left ventricle. The mechanical consequences of this lead to serious accidents and fatal complications. The blood is retained in the left auricle, which dilates, then blood stasis affects the lung (which may lead to an oedema crisis); the right heart is progressively affected where the walls hypertrophy and then dilate, until there is a right cardiac failure, which in the end is fatal. VII, 125, 126.

Mitral valve: a structure shaped like an inverted mitre, situated in the heart muscle and composed of two valves, an anterior and a posterior one. These valves are at the auriculo-ventricular orifice on the left side of the heart and their closing prevents the blood of the left ventricle from going back into the left auricle during the cardiac systole. VII, 118, 119, 124, 126.

Mixed aggregate: formed by the culture of two sorts of cells which unite to make up a mixed tissue. Such aggregates make possible laboratory study of the interaction between cells of different types. I, 74, 75, 76, 77.

Molluscicide: a substance that selectively destroys molluscs that harbour the larvae of parasites. VII, 78.

Mollusc: an invertebrate animal, the body of which consists of a head, a visceral mass and a foot. The visceral mass is covered wholly or partly by a mantle that secretes a shell. The nervous system is in the form of a double oesophageal collar. The body cavity is reduced more or less to the pericardium (the part enveloping the heart) the genital organs and the excretory organs. II, 18, 20, 25, 69.

Mongolism: a relatively rare non-hereditary congenital disorder: it is a variety of congenital idiocy in which the infant, from birth, has a Mongoloid appearance. Morphological anomalies are associated later with mental retardation. This affection is caused by a chromosomic abnormality (appearance of a chromosome supernumerary to the twenty-first pair of chromosomes). Mongols are particularly affected by leukaemia. Synonyms: Langdon-Down's disease, Mongolian idiocy or imbecility. VI, 146, 147; VII, 14.

Monilia: a genus of yeast (blastopore fungi) of which a few species are pathogenic to man and cause local disorders (thrush), or digestive or lung disorders. Synonym: *Candida*. VII, 87.

Monoblast: the source cell of monocytes. VII, 34, 98.

Monocotyledons: a class of plants of the sub-branch of the Angiospermae. Monocotyledons are differentiated from dicotyledons by (1) a seed containing a single cotyledon; (2) a floral type which is in three or multiples of three; (3) leaves with parallel veins; (4) the absence of secondary growth in the stem. Examples are Gramin-aceae, palms, and Liliaceae. III, 50.

Monocytes (or large mononuclear cell): a white cell of large size (15 to 40 microns). The nucleus is round or oval and the cytoplasm is slightly basophilic. IV, 114; V, 28; VI, 43, 45, 132; VII, 34, 98, 101.

Monogenea: small worms *(Microcotyle)* parasitic in fish. Some of these *(Polystoma)* have become parasitic in frogs. They attach themselves to gills of tadpoles and later migrate to the bladder of the adult frog. II, 106.

Monohybridism: the crossing of two individuals from pure stock and differing by only one character. The study of individuals of the first and the second generation from such a cross makes it possible to demonstrate the laws of heredity, called Mendel's laws. I, 188, 119.

Mononuclear: a white cell with a round or oval nucleus, the opposite of polymorphonuclear. See Macrophage and Monocyte. V, 28; VI, 131.

Mosaic: a disease of a number of plants, caused by viruses. The name comes from the 'mosaic' appearance of the leaf attacked, which is covered with small yellow spots with very clear-cut contours. The first protein viruses obtained in crystallized form were those of the tobacco mosaic. Other viruses responsible for mosaic disease have been purified and crystallized (those of potato, tomato and cucumber). I, 15, 16, 54; III, 38, 70; IV, 20, 90.

Monoecious state: the state of a plant in which it has hermaphrodite flowers with stamens and pistils on the same plant. III, 17, 131.

Mosses: a class of the Bryophytes. Mosses are leaved plants living mostly in colonies in damp woods, on walls, rocks or in water. III, 50, 57, 58.

Motor area: an area of the cerebral cortex situated in the frontal gyrus. From this area the pyramidal tract descends. It initiates voluntary movement. V, 70.

Motor-end plate: a place on a striated muscle fibre where the terminal ramifications of a motor-nerve fibre end. V, 65, 67, 126, 146.

Motor-neurone: a neurone of which the cell body is situated in the anterior horn of the marrow and of which the axone provides motor innervation to a certain number of striated muscle fibres. V, 80, 131.

Motor nerve: a peripheral nerve, consisting of motor axones, innervating a striated muscle. IV, 83, 84.

Moult: the phases during which an insect throws off its chitinous cuticle; the moult is caused by a hormone, ecdysone, produced by the neurosecretory cells of the insect. II, 38-41, 44, 45.

Mucilage: see Mucopolysaccharide.

Mucine: a polysaccharide that constitutes the main element of mucous (see Mucosa).

Mucopolysaccharide: a constituent of cell protoplasm and of the fundamental substance of connective tissue. The principal mucopolysaccharides are hyaluronic acid (synovial liquid and connective tissue) and chondroitin sulphate (cartilage). VI, 112, 113.

Mucosa: a complex tissue formed by epithelium together with loose vascularized connective tissue that lines certain natural cavities of the organism and is always slightly damp (oral, nasal, gastric and intestinal mucosa). I, 66; IV, 110, 115.

Mullerian duct: the rudiment of the oviducts and uterus in the female embryo of vertebrates. I, 144-148, 150.

Mummification: slow desiccation of tissues not followed by putrefaction. IV, 68.

Mumps: an infectious, contagious, epidemic, and immunizing disease caused by a virus. The lesions attack the exocrine glands (particularly the salivary glands and the testis) and the nervous system (meningitis). The disease incubates for twenty-one days. VI, 19, 23, 51; VII, 34.

Muramic acid: an acid with nine carbon atoms derived from hexosamine, found in cell walls and spores of bacteria. IV, 24, 25.

Murine typhus: see Typhus, endemic.

Muskeg: vegetation of northern Canada occupying closed basins more or less filled by an accumulation of peat. III, 123.

Mutagenesis: an induction of mutations caused by the action of physical agents (ionizing radiations, x-rays, alpha, beta and gamma rays, and non-ionizing radiations, such as ultraviolet rays) or chemical agents (mustard gas, nitrous acid, abnormal purine and pyrimidine bases, etc.). IV, 32, 33.

Mutant: an individual in which one or more hereditary characters are modified as a result of mutation of a gene. III, 130-132; IV, 32.

Mutation: a sudden hereditary modification of one or more morphological or physiological characters of an animal or plant, resulting from the transformation of one or more genes. Mutation is the inception of a heritable variation. Mutations arise spontaneously or experimentally under the effect of a physical or chemical mutagenic agent (x-rays, ultra-violet rays, mustard gas, etc.). Mutations are one of the mechanisms of the evolution of species. I, 22, 23, 120, 121, 123-126; II, 31, 32; III, 126-135; IV, 18, 37-40, 146, 147; V, 31 et seq.

Mutation rate: frequency of mutations observed at a given gene locus in a population of plants or animals. II, 34.

Mycelium: the vegetative part of fungi. III, 48, 58, 59, 68.

Mycobacteriaceae: a family of bacteria of the order of the Microbacterialae. The main type is the *Mycobacterium tuberculosis hominis* (the tubercle bacillus). The search for bacilli in sputum, urine or spinal fluid is made after staining or by fluorescence. The diagnosis of tuberculosis is based also on culture or inoculation of the guinea-pig. IV, 45, 53, 56, 57, 63, 64; VI, 22, 28, 115; VII, 38.

Mycoses: the name given to all parasitic disorders caused by fungi. VI, 51, 64, 65; VII, 35.

Myelin: a substance constituted by phosphorated lipids and protein, forming a kind of isolating sheath in certain nerve fibres, said, for this reason, to be myelinated. V, 64.

Myeloblasts: cells that give rise to granular leucocytes. Myeloblasts resemble undifferentiated cells. Their presence in the peripheral blood is abnormal; in the bone marrow, on the other hand, they exist in small numbers by the side of more mature cells which are promyelocytes, myelocytes, and metamyelocytes. IV, 103; VI, 131, 133; VII, 98.

Myelocytes: in the development of polymorphonuclear leucocytes myelocytes are intermediate between myeloblasts and adult leucocytes. These young cells are usually found only in bone marrow. VII, 98.

Myocardium: striated muscle constituting the contractile part of the wall of the heart. VI, 33, 84; VII, 26, 120.

Myofibril (or muscle fibril): the fibrils constituting muscle fibre are long thin filaments contained in the fibre and parallel to its axis. They are constituted by bands that are alternately light and dark at regular intervals along the fibrils and giving the fibre its striped appearance. I, 67.

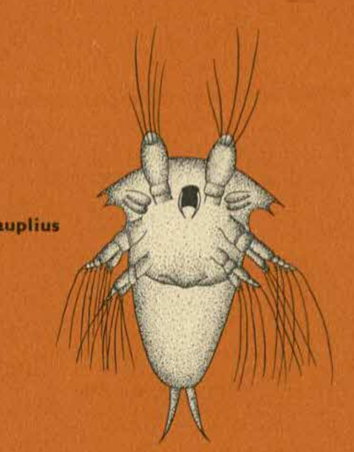
Myoglobin: a specific globular protein of muscle. I, 155, 156.

Myomectomy: excision of a uterine fibroma while preserving the uterus. VII, 110.

Myopia: an anomaly of refraction in which the image of a distant object is formed before the retina when accommodation does not occur. VI, 142.

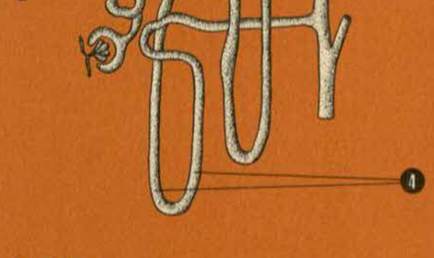
Myoresolution: muscle relaxation essential to the carrying out of a surgical operation. VII, 108.

Myosin: a protein with enzyme properties required for muscle contraction. It forms part of the chemical composition of myofibrils. I, 155; V, 127, 128, 146.

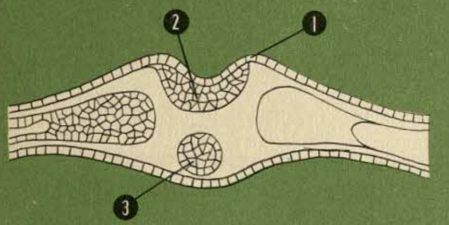


Nauplius

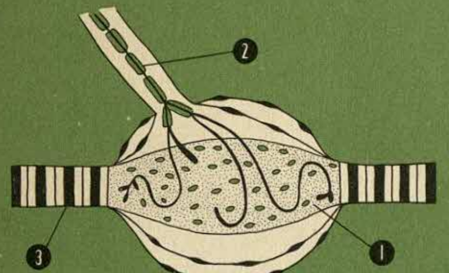
Nautilus



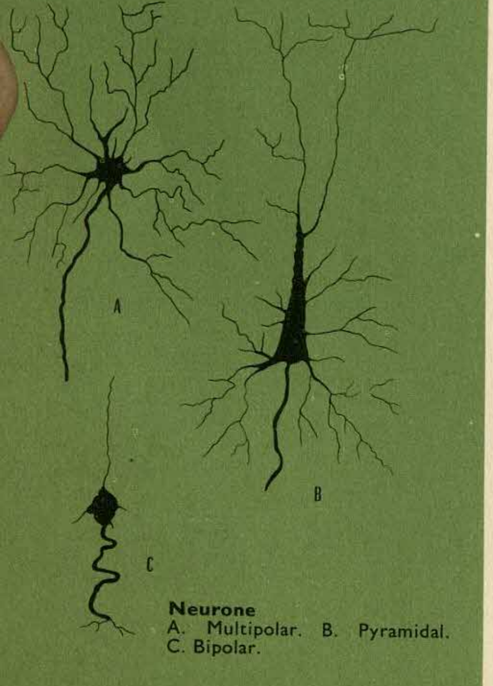
Nephron
1. Glomerulus. 2. Collecting duct. 3. Uriniferous tubule. 4. Henle's loop.



Neural fold
1. Ectoderm. 2. Neural plate.
3. Notochord.



Neuromuscular spindle
1. Neuromuscular spindle. 2. Sympathetic nerve fibre. 3. Striated muscle fibre.



Neurone
A. Multipolar. B. Pyramidal. C. Bipolar.

Myxomycetes: very lowly organisms which are sometimes classified among the protozoa (the lowest of the animal kingsom), or among the protophytes (the lowest of the plant kingdom). They live as plasmodia, then transform themselves into sporangia, and then into spores. III, 11, 12, 48.

Myxosporidia: protozoa that are parasites of fish, where they form cysts. I, 86.

N

Naevus: a congenital malformation of the skin, characterized by a deterioration in its colour and texture: naevi are sharply defined, forming spots or moles of a greater or lesser extent. The pigmentary naevus is the one most frequently found. VII, 30.

Narcoanalysis: a method used for a therapeutic purpose in a patient put to sleep by an intravenous injection of a barbiturate compound and given a psychiatric examination at the moment of waking. Psychological barriers, whether voluntary or involuntary, may disappear temporarily and the patient will express his feelings without any inhibition and bring up subjects that were deep down in his subconscious. VII, 43.

Narcosis: a state of analgesia (absence of pain) accompanied by stupor. Narcosis differs from anaesthesia, in that pain disappears before sleep or unconsciousness occurs, if they do occur. The most frequently used narcotics are morphine, pethidine, codeine, etc; they constitute a special group of depressives affecting the central nervous system. VII, 54.

Narcotics: pharmaceutical substances that cause, especially, insensitivity to pain (analgesia), accompanied by a feeling of relaxation that may lead to sleep. Their action is different from general anaesthetics in that pain disappears before the appearance of sleep. VII, 54, 96.

Nastic movement: in plants, movements the orientation of which is solely determined by the shape of the organ that moves and not by the orientation of the forces at work (tactisms). Nastic movements may be produced even in organs where growth has ceased. III, 12, 92, 93.

Nauplius: the larval stage of certain crustaceans. The nauplius is of ovoid shape, and measures about 0·5 mm. It possesses a digestive tract, a nervous system, an excretory apparatus and, also, a median eye, resulting from the coalescence of three ocelli. I, 88, 89; mi.

Nautilus: a cephalopod forming part of the Tetrabranchiate group, of which it is the only living representative. It lives in groups and feeds on crustaceans. The body occupies the last portion of the spiral shell. Transverse divisions divide the shell into successive chambers, the number of which indicates the animal's age. II, 27, 28, mi.

Necrosis: local death of cells or tissues following certain diseases. VI passim. VII, 28.

Nectar: a sugary secretion produced by specialized plant organs called nectaries, localized at the base of the stamens and pistil. II, 114, 127, 130.

Nemathelminthes: metazoa with triploblastic bilateral symmetry; their nonmetamerized bodies are covered by a thick cuticle of chitin. The sexes are generally separate. There are the nematodes (round worms, eg, *Ascaris*) of which many are parasites, and the Gordiidae (hair worms). II, 17.

Nematocysts: small poisonous structures found in coelenterates. Nematocysts serve for the defence and capture of small prey (*Daphnia*, etc.). I. 109.

Nematodes: a class of nemathelminthes. Nematodes are often parasites. They possess the ability to revive after desiccation. I, 12, 14; II, 17, 59, 60, 61, 62, 150.

Neoblast: a cell of an adult organism that has preserved its embryonic character. In animals capable of regeneration, neoblasts are the origin of newly-formed tissues. I, 109.

Neogenesis: new or autonomous tissue leading to superfluous formations or to a tumour. VII, 29, 30.

Neopallium: in the brain, part of the cortical covering that is the most recent, phylogenetically speaking. V, 87.

Neoplasm: see Tumour. VII, 29. 30, 89, 96.

Neoteny: persistence of larval characters in the adult state in certain animals (particularly in the axolotl, an amphibian that preserves its external gills all its life). II, 33.

Nephelometry: a process of comparing the transparency of a solution with that of a control solution. VII, 41.

Nephrectomy: partial or total removal of a kidney. VII, 110.

Nephritis: a generic term that designates all acute or chronic inflammations of the kidney. Acute nephritis may be classified in two wide categories: glomerulonephritis, of which the initial lesion and the predominant one is glomerular; they are for the most part infectious cases (post-inflammatory nephritis); and the tubulonephritis, usually caused by poisoning (mercurial nephritis). Chronic nephritis may be of many kinds, classified according to the type of renal pathological and anatomical lesions. The classic among chronic nephritis is Bright's disease, associated in varying degree with the following four syndromes: albuminuria, uraemia, oedema and hypertension. VI, 22, 90-95; VII, 34.

Nephron: the elementary constituent of the kidney. Each nephron consists of a glomerulus, a Malpighian corpuscle, a Bowman's capsule and a uriniferous tubule. V, 21, 22, 126; mi.

Nephrotic syndrome: a disease characterized not only by marked albuminuria and a tendency to oedema, but also by an increased level of cholesterol and lipids in the blood and by a diminution of protein in the serum, affecting essentially the albumin. This syndrome corresponds to very variable anatomical lesions in the kidneys, and very different sorts of disorders from the prognostic and therapeutic points of view. In most cases, only renal biopsy (medical or surgical) will lead to an anatomical and etiologically exact diagnosis. VI, 94.

Nephrotoxic: substances that may exert a toxic effect on the kidney. VII, 88.

Nerve ganglion: a small enlargement situated on a nerve, containing the cell bodies of neurones. There are ganglia of the sympathetic nervous system and spinal ganglia found on sensory nerve pathways. VII, 129.

Nerve impulse: a physiological process by which a sensory or motor impulse is transmitted along a nerve. The passage of an impulse in the nerve fibre is shown by a quick change of electric and ionic equilibrium (resting potential) between the inside and the outside of the fibre: this depolarization is called action potential. Chemically, the passage of the impulse gives rise to a change of permeability and an exchange of potassium and sodium ions from one side to the other of the nerve fibre cell membrane. V, 62-67.

Nervous system: the nerve elements of the organism. The cerebro-spinal nervous system conveys sensory perception and voluntary movement; the autonomic nervous system inervates the visceral organs and controls their function; the autonomic nervous system is divided into two large systems with antagonistic actions: the sympathetic system and the parasympathetic system. II, 65; IV, 83; V, 12, 13, 60, 61; VII, 54-57.

Neural axis: the embryonic axis formed by the neural tube, which is the rudiment of the nervous system, coinciding with the bilateral symmetry axis of the organism. I, 135.

Neural crest: in the embryo of vertebrates, a continuous cordon of cells of ectoderm origin, situated on both sides of the neural plate in the angle formed by the latter and ectoderm. The cells of the neural crest migrate through the body of the embryo and give rise to pigment cells in the skin, spinal and sympathetic ganglia, the cartilages of head and neck, and the medullary part of the adrenal cortex. I, 73.

Neural fold: structures of the embryo during the neurula stage. During the course of neurulation, the first rudiments of the nervous system or neural plate are formed by the uprising of the neural folds. I, 135; mi.

Neural plate: first rudiment of the nervous system in the embryo at the gastrula stage. The neural plate is shaped like a shield with raised borders constituting the neural folds. I, 135.

Neural tube: in embryology, the neural tube arises from the fusion of the two neural folds, derived from ectoderm at the moment of neurulation. I, 135.

Neuralgia, cervico-brachial: a syndrome characterized by strong and persistent pain in the hinder outer part of the arm and in the neck and the back of the head, accompanied by sensory disturbances and paralysis. VII, 156.

Neuralgia (sciatic): a syndrome characterized by continuous pain, periodically more acute, in the sciatic nerve, although the nerve itself is not impaired. It may depend on local causes that produce irritation of the nerve roots in the spinal cord (slipped disc). VII, 156.

Neuroglia: a tissue that acts in nerve centres as a support and provides nourishment. Neuroglia is formed by all the cells of the nervous system, but does not play any part in the conduction of impulses. It includes the ependymal cells that line the cavities of the spinal cord and especially Deiters' cells (astrocytes).

Neuroleptic action: sedative central and depressive action on nervous and psychological tension, accompanied by a weak hypnotic action. VII, 151.

Neuromuscular junction: a region of contact (also called the motor-end plate) between the motor-nerve fibre and the striated muscle fibre that it innervates. Here, the membrane of the muscle fibre undergoes important modifications in structure and properties, and it is here too that the muscle action potential arises which is the origin of the contraction of muscle fibre. V, 66.

Neuro-muscular spindle: a proprioceptive sensory organ situated inside striated muscle, in tendons and joints, which plays an essential role in the statics and dynamics of the body by measuring the degree of muscle contraction. When a striated muscle is contracted by means of the neuro-muscular spindle, a reflex action is set up that determines the extension of this muscle. It provides a control system by feedback. V, 100, 130, 131, 132, 159; mi.

Neurone: a complete nerve cell (the cell body with its prolongations, the axon and the dendrites). V, 62-64, 66, 67, 75, 78, 79, 81, 138; mi.

Neurone, bipolar: a nerve cell with a single dendrite, the other pole of the cell giving rise to the axon. II, 74.

Neurosecretion: a function peculiar to nerve cells of a particular type in the hypothalamus, in the posterior pituitary, or in the cerebroid ganglia of certain invertebrates (insects and crustaceans). V, 66.

Neurosurgery: surgery of the nervous system, especially of the nerve centres (section of a nerve connection, removal of a tumour). Neurosurgery of parts of the brain (eg, the hippocampus in the rhinencephalon) leads to the suppression of localized neurological disturbances. VII, 138.

Neuropathy: a disease accompanied by a disturbance of psychological function. Among neuropathological states is neurasthenia. VII, 146.

Neurotoxin: a toxic substance that only attacks nerve cells, generally by inhibiting the function of the synapses (q.v.) or the motor-end plates. II, 148; IV, 81.

Neurotropic virus: a virus (q.v.) that attacks the nervous system selectively (eg, poliomyelitis virus).

Neurula: a stage that follows the gastrula, at the moment of the differentiation of the rudiment of the nervous system on the dorsal side of the embryo. I, 127, 129.

Neurulation: a stage of embryonic development that leads from the gastrula to the neurula and during which the neural axis is formed. I, 133-136.

Neutralization: a reaction that takes place when the addition of an antibody to a corresponding antigen suppresses the toxic effects of the latter. IV, 129.

Neutropenia: a diminution in the number of neutrophil leucocytes. VII, 31.

Neutrophilia: a property possessed by the cytoplasm of certain cells of not being able to fix either basic or acid stains, eg, the neutrophil polymorphonuclear cells. IV, 112, 115; V, 28.

Nicotinic acid: the precursor of vitamin PP (or nicotinamide). The deficiency of one or the other determines the appearance of pellagra and certain nervous disturbances (amnesia, delirium and depression). VI, 14.

Nitrification: the transformation of ammonia into nitrous acid and nitric acid. Nitrification is one of the phases of the nitrogen cycle and is produced in the soil by nitrifying micro-organisms. II, 71.

Nitrobacter: a genus of bacteria present in the soil which transforms nitrous acid into nitric acid (nitrification). IV, 14, 64, 71.

Nitrogen cycle: transformations undergone by nitrogen in nature. Beginning with organic nitrogen (plant proteins and animal proteins) ammonia is obtained, which is then turned into nitrites and nitrates. Nitrates may then undergo two processes: (1) denitrification, leading to atmospheric nitrogen, and (2) proteogenesis, leading to the formation of proteins. The nitrogen cycle is thus a balanced reaction between organic nitrogen and nitrates. I, 17; IV, 71, 72, 74.

Nitrogen mustards: Derivatives of mustard gas, in which sulphur is substituted for the nitrogen atom; these drugs (and there are now many of them) are used in the treatment of malignant disorders, such as cancers, tumours, and malignant haemopathies. They are very toxic and have to be handled with care and under medical supervision (there is a risk of medullary aplasia). VII, 90, 99, 101.

Nitrosomonas: a genus of bacteria living in soil and transforming ammonia into nitrous acid. IV, 14, 71.

Noradrenalin: a hormone of the adrenal cortex that causes the vasoconstriction of the arterioles and the capillaries. In tumours affecting the adrenal cortex (pheochromocytoma), it is produced in too great a quantity and causes arterial hypertension. V, 65; VI, 90, 102.

Normochromic anaemia: a type of anaemia in which the number of red cells is less than normal, but the quantity of haemoglobin contained in each cell is normal. VI, 78.

Normocytosis: the presence in the blood of normocytes (normal red cells of the usual size and without a nucleus). VII, 31.

Nosography: the methodical classification of diseases.

Nosology: the study of distinctive characteristics that permit the determination of a disease. VI, 35, 67; VII, 46, 47.

Notochord: a cellular rod formed by the median band of the mesodermal layer, around which the vertebral column differentiates later. I, 134, 135.

Novobiocin: a little-known antibiotic, active against Gram-positive micro-organisms, but its activity is not very strong and it leads very quickly to resistance. VII, 87.

Nucleic acids: macromolecules essential to life, of a protein nature and formed by chains of a great number of elementary links, the nucleotides. There are two kinds of nucleic acids: deoxyribonucleic acid or DNA, and ribonucleic acid or RNA. DNA, located exclusively in the nucleus, is the essential constituent of chromosomes. DNA gives the cell its reproductive power and its hereditary properties. RNA is found both in the nucleus and the cytoplasm; its main role in the microsomes is to induce the synthesis of proteins. The DNA molecule is like a double helix: it is a long twisted ladder the rungs of which are formed by purine bases and pyrimidine bases and the uprights by a succession of phosphoric acid and a simple glucoside with five carbon atoms, deoxyribose. The bases, numbering four, are attached to each rung according to a rigorous plan: thymine plus adenine, cytosine plus guanine (a purine base plus a pyramidine base). But the succession of base couples may vary infinitely, as well as their spatial molecular arrangement, although in any given species, the DNA of every cell possesses an identical and constant composition. It is now generally accepted that genes, the chromosome particles that transmit hereditary characters from a cell to its descendants, are constituted by groups of bases and that it is the precise order in which the pairs of bases succeed one another along the DNA molecule that constitutes genetic information. Since a DNA molecule generally contains a few dozen thousand nucleotides (each having a base), the number of possible combinations is extremely high and may account for the infinite variation of hereditary characters. The most remarkable property of DNA is its ability to self-reproduce: during cell division each molecule of DNA multiplies itself by duplication, the DNA ladder splits into two longitudinally and each rung, with its particular components, finds in the nuclear fluids the required materials for the synthesis of a new complete rung. Thus the splitting of chromosomes is produced which permits living cells to maintain the same diploid number of chromosomes. The other nucleic acid, RNA, generally has a molecule that is shorter than DNA. Thymine is replaced by uracil and deoxyribose by ribose. Although the structure is not yet known exactly, it appears to be in the form of a simple helix. The composition of RNA is as varied from one species to another as are the different DNA constituents; also, there are in each cell at least two forms of RNA, one in the cytoplasm, localized in the microsomes, cell centres of protein and enzyme synthesis, the other, a labile form that travels from the nucleus to the cytoplasm and carries the 'genetic code': this is the messenger RNA, which is synthesized in the nucleus by modelling on a part of one of the DNA molecules, and transports to the microsomes the instructions given by the genes for the synthesis of specific proteins. The main role of RNA in the cells is the synthesis of proteins, but according to a fairly recent hypothesis, this nucleic acid may also be the material basis of memory, this term being taken in the widest sense. I, 39, 47-54; III, 70, 71; IV, 18, 31, 32, 40, 100, 106; VII, 90, 99, H.

Nucleo-cytoplasmic ratio: the ratio between the size of the nucleus and that of the cytoplasm of a cell (this relationship is modified in malignant cells and the nucleus is increased in volume). VII, 34.

Nucleolus: a corpuscle in the nucleus (q.v.) of the cell that contains a strong concentration or ribonucleic acid (q.v.) (RNA). I, 63; IV, 62; VI, 128.

Nucleoprotein: complex chemical substances resulting from the association of nucleic acids and specific proteins. IV, 39, 40; VII, 90, 91.

Nucleotide: a fundamental link in the long molecule of nucleic acid. A nucleotide is formed by the joining of a base (purine or pyrimidine) with a simple glucoside (pentose) and a molecule of phosphoric acid H_3PO_4. IV, 39-40, 47; V, 51; VII, 91.

Nucleus: essential cell constituent, containing the chromosomes, generally limited by a nuclear membrane that separates it from the cytoplasm. Without a nucleus, a cell is incapable of reproducing and synthesizing living matter; all cells possess a nucleus, even if a rudimentary one, as in bacteria, or possessed one at an earlier stage (red cells). Certain cells have numerous nuclei (striated muscle fibre, some bone-marrow cells). I, 55, 63, 103.

Nummulites: a genus forming a large group of foraminifera, fossils characteristic of the Tertiary era (Nummulitic limestone). These foraminifera are coin-shaped, their diameter varying from a few millimetres to some centimetres. They live on calcareous and sandy sea-bottoms. II, 16, 28, 29.

Nyctotemperature: in plant biology, the temperature measured during a period of darkness, in opposition to phototemperature, measured during the day. These temperatures have a determining influence on the growth of plant. III, 100.

Nymph: in insects undergoing complete metamorphosis, an intermediate stage between the larva and the imago. The insect is then immobile and sometimes covered with a cocoon of silk (in the case of nymphs of Lepidoptera they are called chrysalids). II, 43, 47.

O

Obesity: general hypertrophy of adipose tissue. VI, 111.

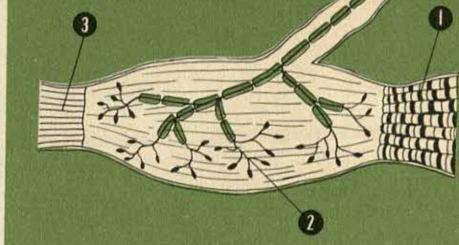
Occupational diseases: illnesses that are peculiar to certain professions: these are caused by physical agents (eg, radiation sickness and diving-bell disease) or by chemical agents (diseases of tanners and cement workers); or they may also be due to poisoning by benzene, lead, etc.); or by inoculation of a pathogenic germ. VI, 67-71.

Ocelli, ocular: patterns formed by dark and light rings simulating an eye possessed by numerous Lepidoptera on their hind wings; these patterns may mystify birds of prey and are a classical example of warning coloration. II, 68, 125, 126.

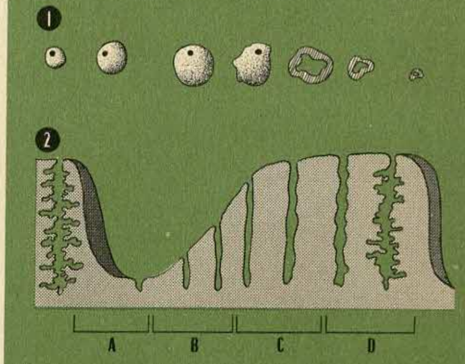
Oedema: retention of interstitial liquid in connective tissue. Pressure with the finger on oedematous skin surface causes a depression through loss of elasticity of the tissue, modified by swelling. VI, 52, 54, 56, 94, 99, 118; VII, 26, 50, 68, 134.

Oestradiol: the principal female sex hormone; secreted by the ovary, oestradiol is a derivative of sterol. It acts on the sexual organs, and the mammary glands, as well as on the metabolism of proteins, fats, calcium and water. V, 57.

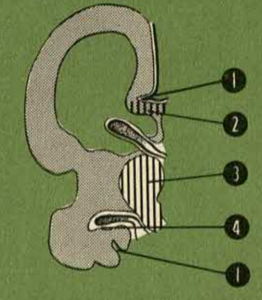
Oestrogen: the female sex hormone secreted by the ovary and also by the adrenal cortex. The main oestrogens are oestradiol and folliculine. V, 52, 57, 58, 137; VII, 35, 94.



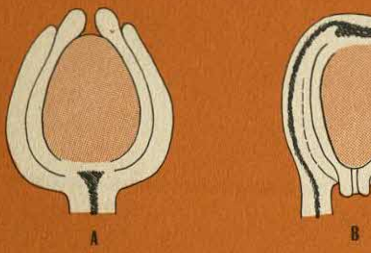
Neurotendinous nerve endings (of Golgi)
1. Striated muscle fibre. 2. Neurotendinous nerve ending (of Golgi). 3. Tendon.



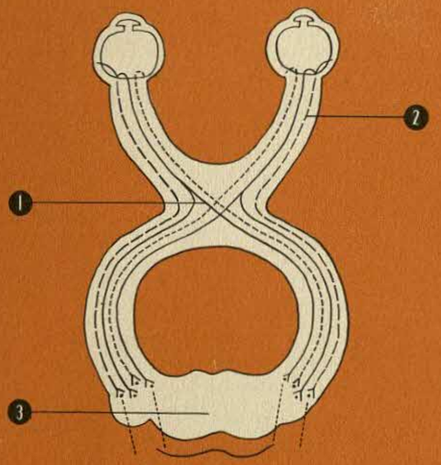
Oestrus
A. Menstrual phase. B. Postmenstrual phase. C. Interval phase. D. Premenstrual phase. 1. Ovum cycle. 2. Uterine mucous membrane cycle.



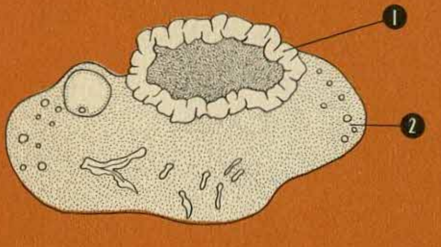
Olfactory lobe
1. Hippocampal commissure. 2. Corpus callosum. 3. Optic chiasma. 4. Inferior horn.



Oosphere
A. Erect oosphere. B. Inverted oosphere.



Optic chiasma
1. Optic chiasma. 2. Optic nerve. 3. Pulvinar.



Ovary (of woman)
1. Corpus luteum. 2. Young ova.

Oestrus: physiological phenomena characterized by desire and readiness for mating shown by female mammals other than the Hominidae. V, 57; mi.

Oleandomycin: an antibiotic that is active orally; it is a purified and crystallized substance extracted from cultures of *Streptomyces antibioticus*. It is active against Gram-positive and Gram-negative bacteria and on certain micro-organisms, e.g. rickettsias and some spirochaetes. VII, 87.

Olfactory bulb: part of the brain where the two olfactory nerves begin. The olfactory bulb is situated in the anterior part of the telencephalon, or fore brain. It is well developed in lower vertebrates (fish and amphibia), but loses its importance in the more developed vertebrates such as mammals. II, 74.

Oligolethical (egg): an egg of very small size (0·1 mm approx.), containing very little yolk, such as the egg of the sea urchin, *Amphioxus* and most mammals. These eggs undergo total and equal segmentation. I, 128, 130; mi.

Ombrophil: a region, particularly a forest, that requires abundant rain for its vegetation. III, 122.

Onchocerca volvulus: a filaria parasitic on man, transmitted by a biting fly, *Simulia*, that is the cause of blindness in thousands of people in Africa. VII, 75.

Ontogeny: the formation of a new living being by embryonic development. In the sexual reproduction of multicellular beings ontogeny starts from one fertilized germ cell. In asexual reproduction somatic cells are capable of producing an organism. I, 19, 26, 107, 133.

Ophthalmoscopy: examination of the retina in the eye by means of an instrument, the ophthalmoscope, that enables light to penetrate and permits examination of the vessels of the retina. This examination is made in darkness and, as the vessels of the retina are directly connected with cerebral vessels, it is possible to obtain some idea of the condition of the latter. V, 103, 104; VI, 143; VII, 136, 137.

Opsonin: a soluble substance that can combine chemically with microbes and facilitates their destruction by white cells (phagocytosis). It exists in serum of normal subjects and in larger quantities in persons immunized artificially. IV, 129, 131; VI, 43.

Optic chiasma: the place in the brain where the two optic nerves join and cross. V, 60, 73; mi.

Organ: a structural and functional association of tissues produced in any multicellular living organism. In certain cases, as in the brain, the organ is constituted of only one kind of tissue, but, more often, it is composed of two kinds, epithelial and connective tissue (this is so in the case of sensory organs and internal and external secretion glands). Organs are grouped in apparatuses or systems, such as the digestive apparatus, constituted by the organs of nutrition and digestion (mouth, oesophagus, stomach, intestine and digestive glands) and also the respiratory apparatus, which includes the larynx, trachea, and lungs. The science that studies the disposition and structure of organs, is anatomy. I, 79-84, 139-142; V, 96, 118, 131.

Organizer: the chorda-mesodermic region of the embryo of an amphibian: a portion of the young gastrula that has the power of 'organizing' an undifferentiated tissue into a neural axis. The organizer is more than an evocator or an inductor, since it causes the formation of axial structures that are well defined and 'harmoniously organized'. A term used for the first time by H. Spemann to describe the 'dorsal quality' of the young gastrula, in opposition to the ventral vegetative hemisphere. The term 'organization' is now used for different stages of embryonic differentiation: primary organizer (dorsal lip of the blastospore that induces the neural axis); secondary organizer (eg, the optic cup that induces the formation of the lens. I, 6, 132, 137.

Orthodromic: nerve impulses that are propagated in a normal manner; that is to say, from the cell body towards the periphery via the axon and from the periphery towards the cell bodies in the dendrites. VI, 66.

Orthopaedics: a word coined by Andry (1741), meaning the art of preventing or correcting body deformities in infants. This definition is now extended to adults and more particularly to the treatment of bone lesions. VI, 38.

Orthotrope: an organ in which the action of weight imposes a vertical direction. III, 63, 66.

Osmosis: a diffusion between two solutions of different concentrations through a permeable or semi-permeable membrane. Osmosis and the pressure that results (osmotic pressure) are general biological phenomena of great importance. They are the origin of such different phenomena as oedema, nutrition of cells and the circulation of sap. III, 16; IV, 46; V, 23.

Osmotic pressure: see Osmosis.

Osteitis deformans: a disease characterized by an increase in volume and deformation of different parts of the skeleton (in particular, the bones of the skull, the thorax and the limbs). It is often accompanied by violent pain. The pathogeny of it is still obscure. VII, 75, 78.

Osteolysis: decalcification characterized by destruction of bony tissues, of which there remains only a connective framework. VII, 98.

Osteomyelitis: inflammation of the cell elements of bone and of bone marrow, caused by the multiplication of staphylococci (most often *S. aureus*). A disease that usually occurs in infancy and adolescence, and is accompanied by general grave symptoms and violent bone pain. V, 59; VII, 104.

Osteoporosis: rarefaction of bone tissue, caused by atrophy of the trabeculae and characterized by the enlargement of medullary cavities and spaces. A common bone lesion in an aged person. VII, 68, 98.

Osteosynthesis: fixation of bones after reduction of a fracture by mechanical means. VII, 144.

Ostium: a part of the oviducts, shaped like a funnel, opening out in the coelomic cavity or in the cavity formed round the ovary; it is the funnel that receives the eggs when they leave the ovary. I, 144, 145.

Ovary: in animals, the female organ of sexual reproduction containing the female gametes (ova) and of which certain cells secrete female sex hormones (folliculine in the Graafian follicle and progesterone in the corpus luteum). In plants, the swollen part of the carpel containing the ovules. III, 13, 51, 54; V, 48, 57, 137; VI, 129, 130; VII, 14, 35; mi.

Ovary, inferior: in botany, an ovary in which the pistil is placed under the perianth. III, 51, 54; mi.

Ovary, superior: in botany, an ovary in which the pistil is placed above the perianth. III, 13, 51, 53; mi.

Oviduct: the tube through which eggs that are freed from the ovary (q.v.) are led outside the body of the animal (in woman, the Fallopian tubes).

Ovotestis: in natural hermaphroditism, a mixed genital gland formed by an ovarian part and a testicular region in certain worms, crustaceans and molluscs (snails). In experimental hermaphroditism this phenomenon may be produced in vertebrates (birds, amphibians and mammals). I, 148, 150, 151.

Ovum: a female gamete, a single cell containing the haploid number of chromosomes, immobile and frequently charged with nutritive substances. After fertilization by a sperm, the fertilized egg becomes a zygote with the diploid number of chromosomes. In Vascular Cryptogam plants the ovum is produced by the archegonia carried on the gametophyte generation. In Phanerogam plants the ovum is one cell contained in the embryo-sac. In multicellular animals the ovum is produced in the ovary. In unicellular organisms, both plants and animals, the ovum is either the organism itself or a product of the division of the organism, in which meiosis has taken place. I, 113; III, 66.

Ovulation: the release of an ovum in a female animal; ovulation (rupture of the Graafian (q.v.) follicle) is produced on about the fourteenth day of the menstrual cycle. V, 59.

Ovule: a structure in Phanerogam plants concerned with sexual reproduction. The ovule is produced by the pistil or carpellary leaves and contains the female spore or embryo-sac which, in turn, contains the ovum or egg-cell, eventually fertilized by a nucleus of the pollen-tube. After fertilization of the flower, the ovule develops into a seed. III, 52, 66.

Oxygen: a constituent element of living matter. Oxygen represents 65% by weight of the human organism. It forms part of water, glucosides (carbohydrates), 'lipids, amino acids and fatty acids. Oxygen is used by most living cells (cellular respiration). It is thus that during the Krebs' cycle there is a consumption of oxygen and the production of CO_2 and H_2O. V, 14, 15, 18, 19, 31, 63, 64, 92, 94; VII, 14, 24, 25, 51, 53, 56, 62, 65, 96, 97.

Oxygenotherapy: the therapeutic use of oxygen in inhalation with an apparatus regulating the flow and gas pressure. VI, 144; VII, 54, 126.

Oxyhaemoglobin: the substance resulting from oxygenization of haemoglobin. Oxyhaemoglobin is formed in the lungs and becomes dissociated in the tissues, liberating the oxygen required for metabolism. V, 18.

Oxytocin: a hormone (q.v.) secreted by the posterior pituitary that selectively stimulates the contraction of smooth muscle, particularly the uterine muscle, at the moment of delivery. V, 52.

P

Pacemaker: a small muscular structure the function of which is to convey excitatory impulses from the auricles to the ventricles of the heart and maintain the normal rhythm of contractions. Failure of the pacemaker leads to heart-block; this can be overcome by the insertion of an artificial 'pacemaker' that conveys electrical excitation to the heart-muscle. VII, 122, 128.

Pachytene: a stage of meiosis (prophase) during which the chromosomes take on a spiral shape and assume the form of short thick rods. It is the stage in which the tetrads are formed, following longitudinal cleavage of the paired chromosomes (see Cell division). I, 117.

Pacinian corpuscle: a sensory tactile organ situated in the subcutaneous tissue, sensitive to deep pressure. Very numerous in the fingers, Pacinian corpuscles, ovoid in form, are constituted by a nerve-ending enveloped in a number of concentric layers. V, 96, 100; mi.

Paget's disease: a rare disorder of the breast found in women over the age of forty and characterized by lesions of the skin recalling eczema and a progressive infiltration of the mammary gland, resulting in a true malignant tumour. VII, 75, 78.

Paget's disease: see Osteitis deformans.

Pairing: in the most general sense, the union of two individuals of different sex, of the same species, with a view to reproduction. I, 111.

Pairing, chromosome: also called synapsis. The apposition of chromosomes during the zygotene stage of meiosis. At this stage the long and flexible chromosomes approach in pairs and become attached to one another along their whole length. They then separate, each of them going to one of the poles of the cell that is dividing. Chromosome pairing is observed also in certain mitoses called endomitoses, during which the chromosomes of the same pair place themselves in parallel with one another and remain together after cleavage. The giant cells of the fruit fly, or *Drosophila*, are formed by endomitosis. I, 116.

Palaeopallium: see Archipallium.

Panchronic (or living fossils): living organisms which appeared in very ancient times, the physiological and anatomical characters of which have not shown any marked change during an extremely long lapse of time. These 'living fossils' may belong to any animal or plant group: eg, horsetails, ginkgos, *Collembolas*, *Apus* and coelacanths. II, 25, 26, 27.

Pancreas: an abdominal gland near the duodenum. It consists of two parts: an exocrine gland that secretes digestive enzymes that act on proteins and which are poured through the pancreatic duct into the duodenum; and an endocrine gland that secretes insulin in the islets of Langerhans (beta cells); this is a hormone which keeps down the level of sugar in the blood and is deficient or absent in sufferers from diabetes mellitus. V, 13, 48; VI, 97, 105, 120; VII, 105.

Pandemic: an epidemic striking nearly all the inhabitants of a country and possibly extending over a very wide geographical area. (eg, plague or cholera.) IV, 95; VI, 31.

Panoptic method (or Pappenheim's staining method): staining that is practised on air-dried blood smears. In red cells, it shows up some parasites, flagellated protozoa such as *Leishmania*, and trypanosomes. VII, 30.

Panspermia (or panspermy): a theory according to which the first seeds of life fell on this earth from other planets, through inter-stellar space. II, 55.

Papanicolaou's method: a differential staining method to show up acidophilia or basophilia in cytoplasm; it is a combined method, since it also colours the cell nuclei. The coloration of cytoplasm is obtained with two stain solutions, orange G and a mixture of light green, Bismarck brown and eosin. The coloration of nuclei is obtained by haematoxylin. This method is used in cancer research in desquamated tumoral cells (expectoration, pleural or peritoneal liquid, and lymph fluid). VII, 30, 35.

Pappenheim's method: see Panoptic method. VII, 30.

Papillary stasis: marked arrest or slowing down of the flow of venous blood, characterized by a distension of the veins of the retina. It is evidence of intra-cranial hypertension (generally a tumour). VII, 136.

Papilloma: a benign tumour of skin (verruca) and mucosa, characterized by hypertrophy of the normal papillae. IV, 100; VII, 30.

Para-aminohippuric acid (PAH): an acid used in investigations of the kidneys. The substance is filtered by the glomerulus and excreted by the tubule (see Nephron). Its clearance is 600 to 700 cc/minute, of which only a small part, 120 cc, comes from glomerular filtration. VI, 24, 26.

Parabiosis: the joining, by grafting or temporary union, of two embryos or two individuals, or of two or more organisms which live side by side with circulatory and fluid exchange. I, 148, 150.

Paralysis: a diminution or abolition of muscular movement. There are a number of varieties, depending on the intensity of the phenomenon (complete or incomplete paralysis and paresia), its topography (monoplegia, paraplegia and hemiplegia), and its cause (central lesion or disease of a peripheral nerve). VI, 35, 37, 38, 78, 82.

Paramecium: a ciliated Protozoon (Infusoria). I, 101, 103-106.

Paraplegia: paralysis of the two upper limbs or the four limbs (quadriflexia). This term is not much used, except to designate paralysis of the two lower limbs. It may be due either to a lesion of the anterior horns of the spinal cord or a bilateral and symmetrical lesion of the spinal nerves. VII, 117.

Parasite: an animal or plant organism that cannot live and develop except at the expense of another organism. Parasitism is a very general phenomenon that is to be found everywhere: there are parasites in nearly all groups of invertebrates, in many Protozoa, and in bacteria. All viruses are parasites. In the plant world, from fungi to Phanerogams (*Cuscuta* and mistletoe), many species are parasites. There are even animals that are parasites of plants (plant fleas) or plants that are parasites of animals (microscopic fungi, such as *Trichophyton*, which give rise to a disease called tinea). There are also some groups of insects which are parasites of parasites (hyperparasites). The degrees of parasitism are very varied; it may be said that heterotrophic (q.v.) organisms are parasites in relation to autotrophic (q.v.) ones, but the term parasite is generally reserved to an organism that lives on or in another organism called the host. There are ectoparasites and endoparasites. The former live on the surface of their host and are not attached to it; eg, lice and fleas. Endoparasites live attached to their host either in the tissue or the digestive tract, or in the blood, or even inside cells; such are viruses, the parasite of malaria, etc.; these are the most numerous. In most cases, parasitism implies an initial physiological modification that renders the parasite incapable of surviving by itself; this state results from the loss of ability to synthesize certain elements essential to life; but it is impossible, because of the infinity of parasitic forms, to provide a common definition of such modifications. There exist, in all parasitic organisms, a number of common morphological characters, shown by the loss of certain organs or certain functions, and the exaggeration of the function of reproduction; eg, in *Sacculine*, and *Taenia*, the circulatory digestive, respiratory and locomotor apparatus have disappeared; there only exists the genital apparatus, well differentiated and hypertrophied. Sometimes a parasite has only a single host; but very often, in order to survive and reproduce, it needs, at different physiological stages, a number of different hosts, whether animal or plant. Thus certain parasitic cycles are very complex: eg, those observed mostly in parasitic worms (*Bothriocephalus*, and liver fluke). II, 105 et seq 118, 154-158; III, 11, 12, 68-72, VI, 10, 14, 22, 23, 40, 68-72, 118, 154-158; VI, 10, 14, 22, 23, 40, 41, 42, 43, 44, 45, 46, 55, 56, 65, 110.

Parasympathetic system: the system of motor nerves that leave the central nervous system in the cranial and sacral regions and innervate the viscera (smooth muscles, glands). Its action is antagonistic to that of the sympathetic system. The most important of these nerves include the vagus (the tenth cranial nerve) that innervates the heart, stomach, and small intestine, and the splanchnic nerve that innervates the large intestine, kidneys, bladder and genital organs. Acetylcholine is liberated at the end of the parasympathetic nerve fibres and causes vasodilation, the slowing of peristaltic movements and cardiac contractions. V, passim; VII, 129, 130.

Parathyroid: an endocrine gland, situated on the posterior side of the lateral lobes of the thyroid gland; it plays an important part in the metabolism of calcium. VI, 97; VII, 105.

Paratuberculous bacillus: this bacillus has a morphology and characteristics that are very close to those of the tubercle bacillus (acid and alcohol resistance), without having any of its pathogenic characters. VII, 35.

Paratype: the complex of characters common to an environment exercising an influence on the manifestation of hereditary characters. IV, 124.

Parenchyma: a term little used in general biology, but used formerly by anatomists for glandular masses and secretory tissues, such as the liver, kidney and pancreas, with a spongy appearance. In botany, it is the name given to tissue constituted by cells that are taller than wide with thin cellulose walls. When these walls have become lignified, it is ligneous parenchyma; when they are formed of suberine, it is suberized parenchyma, or cork. I, 95, 98; II, 18; III, 25, 36, 149; IV, 17, 18.

Paresia: incomplete paralysis.

Parkinson's disease: a disease characterized by a special kind of trembling, especially pronounced in the fingers (crumb-making movements) and a muscular rigidity that gives the patient a particular attitude and a fixed facial expression; it is due to a lesion of the corpus striatum and of the locus niger in the brain. VI, 70; VII, 138, 150.

Paronychia: see Whitlow.

Parotid: a salivary gland in front of the ear, leading into the mouth through the parotid duct and secreting a fluid saliva. VI, 120.

Parthenocarpy: the development of fruit without fertilization (comparable to parthenogenesis). III, 66, 128, 132.

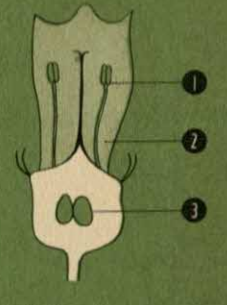
Parthenogenesis: development of the ovum in the absence of spermatozoa. 'Natural' parthenogenesis is known in numerous invertebrates (insects and crustaceans) where it is a normal method of reproduction. In certain cases, it may occur as an accidental character. In other groups (amphibians and mammals), it has been possible to cause artificial parthenogenesis by mechanical or chemical means. E. Bataillon's experiments on an amphibian's egg are among the best known. I, 27, 111, 112; III, 19.

PAS or Para-Amino-Salicylic acid: an amine derivative of salicylic acid with bacteriostatic properties against tubercle bacilli. VI, 26-28; VII, 86.

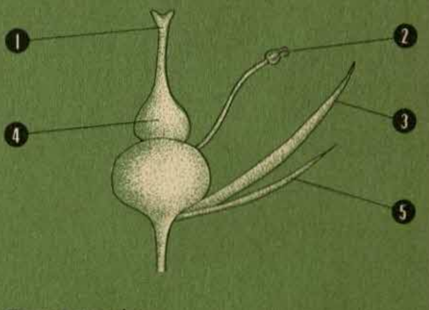
Pathogenesis: the study of pathological mechanisms. VII, 46, 47.

Pathognomic: that which is particular to a disease; a symptom that is found only in a given pathological condition and sufficient in itself to characterize it and to enable a diagnosis to be made. VII, 35.

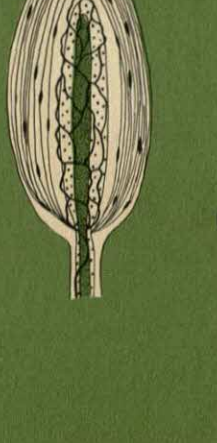
Pathological anatomy: the study of diseased organs and tissues, using laboratory methods of observation (histology, cytology, special staining methods, etc.). Pathological anatomy is constantly used to facilitate or confirm diagnosis. Some diseases damage organs and tissues characteristically; either microscopically or macroscopically. In order to show these modifications, healthy organs and tissues are compared with unhealthy ones. Pathological anatomy has made remarkable progress in the recognition and early detection of some disorders, particularly cancer. In order to obtain the fragments of organs or tissues required, a number of methods are used: autopsy, which provides information only about the state of the organism after death, but is the basis of pathological anatomy; biopsy, which is an essential method in the diagnosis of deep cancers and is sometimes completed by the culture of tissues taken from the organism, enabling an estimate to be made of the rate of multiplication of cells; the taking of cells from natural secretions such as gastric juices, prostatic fluid, saliva and uterine exudates—this method of cytodiagnosis has given immense services in the diagnosis of uterine cancer; and finally, blood- or bone-marrow smears, which are used to



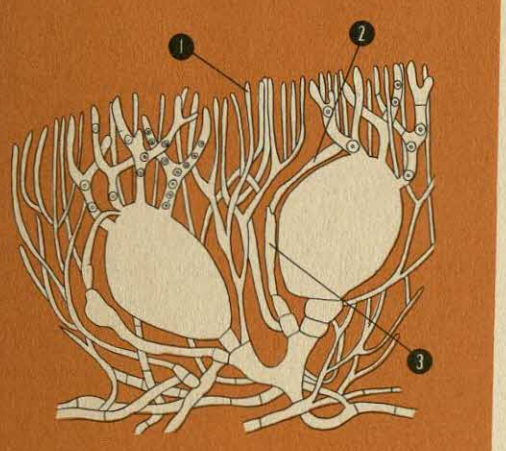
Ovary, inferior
1. Stamen. 2. Petal. 3. Ovary.



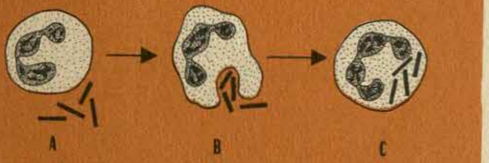
Ovary superior
1. Pistil. 2. Stamen. 3. Petal. 4. Ovary. 5. Sepal.



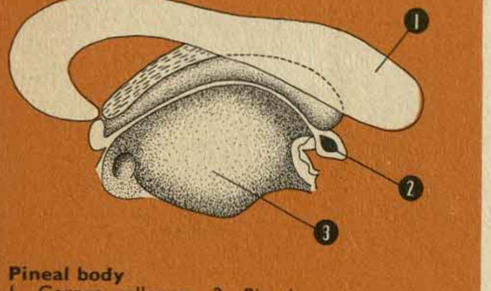
Pacinian corpuscle



Perithecium
1. Hyphae. 2. Female branch.
3. Male branch.



Phagocytosis (Polymorphonuclear leucocytes)
A. Bacilli in the blood stream.
B. The leucocyte emits pseudopods. C. The bacilli engulfed.



Pineal body
1. Corpus callosum. 2. Pineal body. 3. Optic chiasma.

diagnose leukaemia. Blood-cell smears are also used in the recognition of anaemias and certain infectious diseases in which the normal percentage of various elements of the blood are notably modified (for example, a great increase in the proportion of white eosinophil cells). VII, 29-37.

Pectins: the product of condensation of monosaccharides (constituted by carbon, hydrogen and oxygen); widespread in the plant world, where they form a 'cement' between cells. IV, 68, 69.

Pedogenesis: the formation of soils. III, 122.

Peking duck: a variety of duck used by J. Benoit in 1957 in his famous experiments of induced mutation. Injection of DNA extract from a khaki duck into a Peking duck caused the latter to undergo stable morphological transformations. It has not been possible to repeat this experiement. I, 51.

Pelagic larvae: larvae that live in the open sea and move freely. II, 57.

Pellagra: a disease characterized by erythema associated with oedema in the exposed parts of the body, developing in bouts and ending by scaly desquamation. It is accompanied by digestive disturbances (red tongue, gastritis and diarrhoea) together with psychological disturbances. It is caused by a deficiency of vitamin PP. VI, 15, 109.

Penicillin: a powerful antibiotic substance extracted from a culture medium of *Penicillium notatum*. In the pure state, in the form of its sodium salt, it is a white, chemically defined crystalline powder. All local or general infections caused by staphylococci, streptococci, meningococci, pneumococci and bacilli (perfringens, diphtheria, spirochaete, and treponema, or syphilis bacterium) are successfully combated by means of penicillin. Nevertheless, numerous germs are resistant to it, particularly the staphylococci; the quantities of penicillin given must then be considerably increased, up to 60 to 120 million units per day (instead of 1 to 5 million) and other antibiotics must be used, according to the resistance of the germs to different antibiotics alone or in association. III, 72, 153; IV, 18, 42, 119, 144, 146; VI, 31-33; VII, 73, 83-85, 87, 151.

Penicillinase: an enzyme produced by certain microbes that destroy penicillin. Certain bacteria are penicillin-resistant owing to the penicillinase that they secrete. VII, 84, 85, 87.

Pepsin: an enzyme secreted by the chief cells of the gastric glands. Pepsin attacks proteins which are then dissociated into polypeptides; it is the initial stage of the digestion of protein. V, 136.

Peptic ulcer: a disorder consisting in a loss of substance, to a greater or lesser depth, of the gastric or duodenal mucosa; it is characterized clinically by very sharp pains that are clearly localized, and epigastric pains that occur with a double periodicity—daily and at certain intervals between meals (a periodicity of three or four times, according to the seat of the ulcer). There is a variable period of no pain between the crises, which are themselves of variable duration. VII, 47, 58, 151.

Peptone: a product of the digestion of protein substances of plant or animal origin. IV, 62.

Perfusion: a laboratory technique which consists of irrigating an isolated organ through its normal circulatory channels. This technique enables the action of certain drugs to be estimated on the organ being perfused and to measure the products of its metabolism. I, 80.

Perianth: the floral coverings of a flower. The perianth is composed of calyx, or sepals (q.v.), and corolla, or petals (q.v.). III, 64.

Periarterial sympathectomy: resection of the nerve plexus or of the periarterial sympathetic nerve along a greater or lesser part of its length by removing the cellular sheath of the arteries of the limb concerned and cutting it. This operation is performed for obliterating arteritis or in high blood pressure (in this case it is periaortic sympathectomy, which is removal at the level of the adrenals); this operation is also associated with removal of the adrenal gland on one side. (Smithwick's operation). VII, 130, 131.

Periderm: scar tissue that replaces the epidermis in a wounded plant. Suberized periderm is a form that contains substances analogous to cork. III, 71, 72.

Periophthalmus: a tropical bony fish which, during an important part of its existence, lives outside water. III, 35.

Peripatus: a class of arthropods living in warm regions of the earth. *Peripatus* are elongated and cylindrical with two antennae and numerous short feet. They are terrestrial and live in dark, damp places. II, 25, 26.

Peritheca: the fructification organ in certain fungi, eg, *Sporomia*. The peritheca contains the asci. III, 59; mi.

Permafrost: soil that is perpetually icy owing to the average temperature in the region where it exists. Such soil is impermeable. III, 124.

Pernicious anaemia: see Anaemia.

Persistence: the length of time an insecticide remains active. II, 150, 151; VII, 74.

Petal: in a flower, part of the perianth inserted in the floral receptacle, forming the corolla. Petals vary in number according to the genus and class of the plant. III, 49.

Petiole: the leaf stalk that attaches the leaf to the stem.

Petri dish: a small flat glass dish filled with gel on which micro-organisms are cultivated. IV, 148; VI, 2, 16.

Petrochemistry: an industry, dating from 1925, derived from the petroleum industry, which produces a variety of chemical compounds, such as solvents, plastics and artificial fibres. III, 147.

pH: the negative exponent of ten that expresses the concentration in hydrogen ions that are free in a liquid. A pH 7 indicates a neutral solution. Lower values, down to zero, indicate increasing acidity. Higher values, up to 14, indicate increasing alkalinity. IV, 58; V, 27, 94; VII, 28.

Phage: see Bacteriophage.

Phagocyte: a cell that absorbs foreign particles, incorporating them into its cytoplasm (see Phagocytosis). IV, 111-115; VI, 23, 43, 49, 59, 62; VII, 82.

Phagocytosis: a property possessed by certain animal cells of absorbing foreign particles by means of mobile cytoplasmic prolongations, pseudopodia. In the presence of a foreign body (food, dust or a microbe), the phagocyte puts out two pseudopodia or pseudopods. The particle is then surrounded by a vacuole which is digested by cell enzymes or rejected in the form of pus, if it consists of microbes. The most commonly found types of phagocytes are the unicellular amoeba and the white cells of the blood (leucocytes) among the multicellular organisms. The white cells (polymorphonuclear, monocyte, and macrophage cells) constitute a defence against microorganisms in animals. At the slightest alarm, attracted by chemotactism, these cells, coming from lymph nodes or the blood circulation, become massed on the site of the bacterial invasion and destroy the invader. In certain cases this defence barrier is defeated and the infection is generalized. The mechanisms of phagocytosis have not yet been completely elucidated, but during the last few years microcinematography has made a great contribution to the understanding of this phenomenon, which is essential to survival. I, 47, 48, 66; IV, 86, 111, 112, 114, 122, 129, 130; V, 31; VI, 23, 43, 49, 59, 62; VII, 31, 53; mi.

Phanerogams: plants in which the reproductive organs are visible; the opposite of Cryptogams. These are flowering plants, including the Gymnospermae and the Angiospermae. III, 50, 52.

Pharmacology: a science devoted to the study of toxic substances and drugs and the experimental analysis of the actions that they exert on an organ or an organism. Pharmacology is the basis of rational treatment: after preliminary laboratory tests, and then chemical and physiological tests on an animal, the doctor proceeds to clinical trials, which, if they are satisfactory, will lead to the general use of new drugs. VII, 6, 149-151; H.

Pharynx: the tube situated in front of the vertebral column at the back of the mouth. The pharynx is at the junction of the digestive and respiratory system. I, 95, 98; VII, 94.

Phase contrast: the phase contrast microscope distinguishes the fine structure of objects that have little contrast. By the use of an optical device, the phase modifications of light, due to the difference of the refractive index of different parts of the object, are transformed into contrasts of amplitude. I, 60-63.

Phenocopy: an individual in which the phenotype resembles a different genotype to the one possessed by itself. It is produced under the effect of factors in the environment. (See Phenotype). IV, 33, 35.

Phenolsulphonaphthalein: a chemical substance used to ascertain the function of the kidney. It is excreted by the tubule of the nephron and its clearance is 400. A diminution of this clearance suggests a diagnosis of a lesion of the renal tubule. V, 23, 24.

Phenotype: all the visible characters of an individual, whether hereditary or not. Two individuals that are phenotypically similar may not necessarily have the same genotype. I, 116, 123, 124, 125; II, 144; III, 67; IV, 32, 34, 122, 124.

Phenoxymethylpenicillin: an antibiotic obtained by the addition of phenoxyacetic acid to the culture medium of *Penicillium chrysogenum*. It is stable in the presence of acid, and for this reason has a wide clinical application as a penicillin preparation to be administered orally. VII, 84.

Phenylalanine: an amino acid that cannot be synthesized by the human organism and is essential for nitrogen equilibrium; it must therefore be provided in sufficient quantity through the diet. VI, 11.

Phlebitis: an acute inflammation or a chronic and subacute disorder of a vein, leading to thrombosis (obstruction) of the vein, which may be caused by a deterioration of the vascular wall (sclerosis), by hypercoagulability of the blood and by a slowing of the circulation, leading to blood stasis. Phlebitis, or venous thrombosis, begins with an acceleration of the pulse, then an increase of temperature, with a sensation of pain and the formation of oedema in the part that has been affected. Untreated, it may cause serious lung embolisms, or leave painful sequelae (varicose veins). VII, 134.

Phlegmon: inflammation of connected tissue that separates organs, leading to an extended necrosis of the inflamed tissues. VI, 15, 19.

Phloem, or bast: a tissue in plants, that contains the nutritive sap produced in the leaves. In trees, it forms the internal part of the bark and may be many-layered. III, 46, 149-151.

Phonation: the emission of sounds, articulated or not, by the larynx, in numerous species of vertebrates. V, 133, 134.

Phosphagen: a chemical substance (creatine-phosphoric acid) formed in muscle at the moment of muscle contraction. Phosphagen is used for reconstituting ATP. V, 127.

Phosphorylation: a process in which a phosphorus acid molecule combines with a sugar which is thus transformed into a very active product in the chain of biochemical reactions. III, 26, 27, 36, 37.

Phosphotungstic acid: an acid employed to obtain a contrast in biological objects observed under the electron microscope. IV, 21.

Photochemistry: the study of chemical reactions requiring light as a source of energy, as is the case in photosynthesis. III, 26, 27.

Photoperiodicity: this term is applied to the directing, by means of the duration of light during the day (photoperiod), of biological processes which, in higher plants lead to germination, dormancy, or flowering. This phenomenon depends on the relative length of nights and days. This fact has led to the distinction between three groups of plants: long-day plants, in which flowers do not form unless the twenty-four-hours day illumination is sufficiently long (eg, spinach, corn and spring oats); short-day plants, in which flowering cannot be produced except in the season when the nights are long (eg, the chrysanthemum); finally, plants in which the duration of light is of no importance in the formation of flowers. The mechanism of photoperiodicity, which for a long time was not understood, is now beginning to be elucidated: it is a chemical reaction that requires the intervention of light (photochemistry) that activates a cell pigment, phytochrome, that acts like an enzyme; that is to say, a catalyst. Phytochrome exists in two forms, one form absorbing light-red light and the other the active form of the enzyme, absorbing dark-red light. When a plant is placed in darkness, the pigment is spontaneously transformed into its inactive form (absorbing light-red) which would have the effect of inhibiting certain fundamental metabolic processes, in particular, those dealing with germination and flowering. It is this reconversion of phytochrome that allows the plant to 'measure' the number of hours of darkness and thus to distinguish long nights from short ones. III, 19, 108-112.

Photosynthesis (or carbon dioxide assimilation): a complex physiological mechanism by means of which green plants with chlorophyll are capable of capturing atmospheric carbon dioxide and transforming it into living matter, using the rays of the sun as a source of energy. Green plants represent, therefore, by means of photosynthesis, the typical autotrophic organisms; except for certain bacteria that carry out chemosynthesis, they are the main suppliers of organic carbon compounds to the living world. In brief, and taking into account only the final result, photosynthesis can be summarized as follows: a reduction of atmospheric carbon dioxide by means of the hydrogen in the water vapour of the atmosphere, with the formation of a very simple organic compound $(H\text{-}CHO)^n$ and rejection of an oxygen molecule. In fact, the phenomenon takes place in two successive main stages, the luminous stage and the dark stage. During the first stage, chlorophyll captures the energy of light rays, leading to the decomposition of water into hydrogen H^+ and hydroxyl OH^-. This reaction occurs in the chloroplasts and requires the presence of chlorophyll *a* (the chlorophylls *b*, *c*, *d*, only intervene secondarily). The second stage, which does not require the intervention of light, nor of chlorophyll, is the phase of assimilation of carbon. The reactions of the dark phase occur in a few seconds and are multiple: they quickly lead to the formation of an organic compound with three carbon atoms; it has not yet been possible, however, to reconstitute all the stages of this synthesis. Then, after a few minutes, glucose is formed, with certain simple lipids and some amino acids. During the dark stage, photosynthesis uses the same metabolic stages as respiration, especially the Krebs cycle, and the same enzymes and the same vitamins take part as in those two fundamental phenomena of metabolism. I, 69; III, 12, 16, 22-30, 100, 145.

Photosynthetic quotient: the ratio of the volume of oxygen absorbed by green plants to the volume of carbon dioxide exhaled during photosynthesis. This quotient is usually equal to one. III, 22, 30.

Phototemperature: see Nyctotemperature.

Phototropism: the orientation of growth of plants in relation to light. There is positive phototropism (stems growing towards light) and negative phototropism (stems growing in the direction of the weakest luminosity). Phototropism is linked with a growth hormone called auxin. III, 94.

Phycocyanin: a carotene pigment of blue Algae that makes photosynthesis possible. III, 25.

Phycoerythrin: a carotene pigment of red algae performing photosynthesis. III, 25.

Phyllotaxis: the arrangement of leaves on a stem in relation to its axis. Most recent research has shown that the leaves are inserted into the stem along a number of leaf spirals. III, 62.

Phylogenesis: the study of the paleontological development of the species. I, 18, 26.

Phylogenetic relationship: belonging to similar related families evolved from common ancestors. II, 67, 80.

Phytochrome: a plant pigment that plays the part of an enzyme in the chemical reactions of photoperiodism. Phytochrome exists in two forms each of which may be transformed into the other: one form absorbing light-red light, and the other dark-red light. III, 111, 112.

Phytocoenosis: a surface covered by plant populations of the same flowering nature. III, 114.

Phytohormones (also called growth hormones): substances that multiply and elongate plant cells and which, in a manner comparable to that of animal hormones, are transported from one part of a plant to another and behave like chemical messengers. Certain plant hormones stimulate growth; others, less known, behave like inhibitors, preventing seeds from germinating or buds from opening in unfavourable conditions. The main phytohormones of growth belong to three groups, the auxins, the gibberellins, and the kinins; each of these groups includes substances which sometimes have very different chemical formulae, but analogous physiological effects. The auxins act especially on the elongation of the parts between nodes of the stem, cell division in the cambium and roots, and cell permeability to water; they inhibit the development of buds. The gibberellins are very active in the development of buds; they also accelerate the elongation of stems, and cell division in the meristems, the flowering of plants (see Photoperiodicity) and the germination of seed. The role of kinins appears to be the regulation of cell division: these substances are probably concerned in the metabolism of nucleic acids. I, 32, 89, 90; V, 23, 48, 49, 50, 52, 122, 134; VI, 96-99, 102, 103, 106, 107, 120, 127, 129, 130, 134, 135.

Phytopharmacy: the study of chemical products used in the protection of cultivation. II, 148.

Phytotron: the complex of apparatus used in plant physiology to create artificial climates or re-create natural climates artificially in order to study each variable. In a phytotron it is possible to regulate all climatic factors, such as temperature, air humidity, intensity and duration of daily and annual light, and the influence of each of the various radiations of white light. Each variable factor in a climate may thus be controlled in advance, and the phytotron, owing to the fact that observations and results can be rigorously repeated, enables a rational study of the growth of plants and the fundamental mechanisms that govern plant life to be made. It is possible, for example, to try to elucidate the mechanism of two complex phenomena: thermoperiodism and photoperiodism; and to carry out research into the optimal conditions of germination, of vegetative growth, or the flowering of plants. It is possible with this method of creating artificial climates to determine the conditions of best yield for the cultivation of plants required as food: these problems are of primary importance owing to their economic significance. III, 96-98, 157.

Pia mater: an internal membrane of the meninges, covering the brain and spinal cord.

Pigment cells: cell containing or secreting pigment. In mammals, pigment cells are most frequently found in the sensory organs and the skin. There are two types: chromatocytes, which produce their own pigments, and chromatophores, which generally acquire their pigments by phagocytosis. In certain animals, the pigment cells are of many colours. Some kinds of protective coloration occur because these cells can vary in size (chameleon, cuttlefish, ray). I, 73, 74, 75, 76, 77.

Pigments: coloured substances contained in animal or plant cells, the molecules of which most often contain metallic ions of variable valence which play an important part in the transport of electrons and transfers of energy. Pigments take part in many metabolic reactions; chlorophyll in photosynthesis, haemoglobin in oxygen transport, cytochromes in the Krebs' cycle, etc. There are numerous pigments (especially bacterial pigments) the role of which is still unknown. III, 16, 70, 104, 110, 112.

Pineal gland (or epiphysis cerebri): a small gland situated on the roof of the brain in vertibrates. It is an endocrine gland, the role of which is not yet fully understood. It probably has a retarding action on growth and puberty. In lower vertibrates it was a functional eye. V, 60; mi.

Pinocytosis: a biological process that enables cells to feed by introducing nutriment in the form of small drops into the centre of their cytoplasm by means of deep fissures in their surface. The droplets thus absorbed are fragmented into tiny vacuoles that are soon surrounded by enzymes and digested. Pinocytosis, reminiscent of phagocytosis, is more widespread than the latter, in the plant world as in the animal world. It is very easily observable in cells that are specialized for the function of nutrition, such as the ciliated cells of the intestinal mucosa; pinocytosis exists also in Amoeba, at the same time as phagocytosis. I, 47, 48; mi.

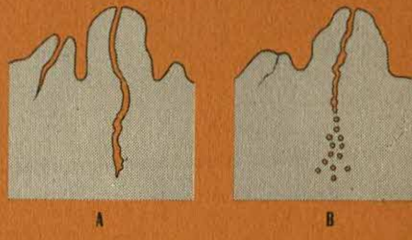
Pistil: the female organ of a flower, composed of three parts; the hollow elongated ovary, the solid style, and the stigma. III, 64, 66.

Pitressin (or vasopressin, or antidiuretic hormone): hormones secreted by the posterior pituitary that stimulate the reabsorption of water in the renal tubule. V, 23.

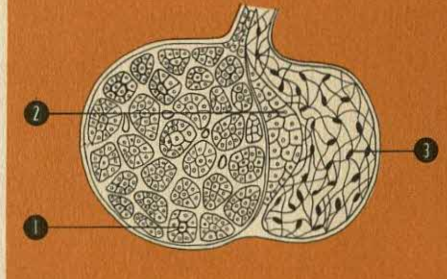
Pituitary: an endocrine gland, situated on the ventral side of the diencephalon and lodged in the sella turcica of the sphenoid. It is formed by three lobes: (1) the anterior lobe which secretes a growth hormone, hormones that are active in metabolism (hyperglycaemic substance) and stimulins (gonadostimulin, ACTH, thyrotrophic and prolactin); (2) the intermediate lobe; (3) the posterior lobe, of nervous origin, which secretes three hormones acting on the smooth muscle of the uterus (oxytocin), on increase of blood pressure (vasopressin) an on inhibition of diuresis (adiuretin). V, 48, 49, 54, 55, 59, 140, 147; VI, 57, 97-99, 101, 102, 106, 119, 130; VII, 14, 35, 136.

Placebo: pharmaceutical preparations, whether tablets, drops or syrups, that contain no active principle, but only inert products, yet have the same shape and colour as those of a prescribed drug. VII, 153.

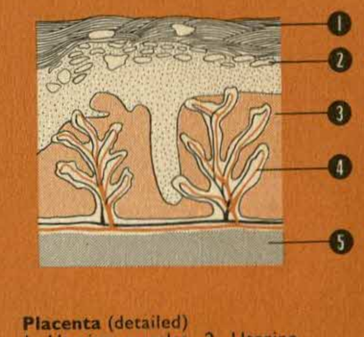
Placenta: a specialized organ formed from



Pinocytosis
A. Beginning of pinocytosis. The membrane has a large invagination. B. Later stage: the invagination is broken up into globules.

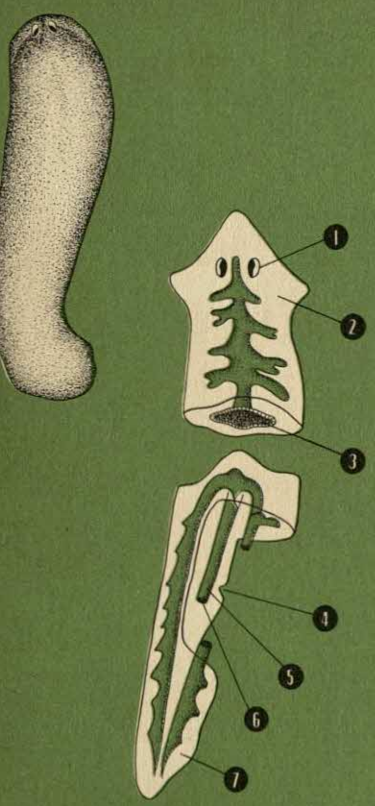


Pituitary
1. Anterior lobe. 2. Pars intermedia. 3. Posterior lobe.

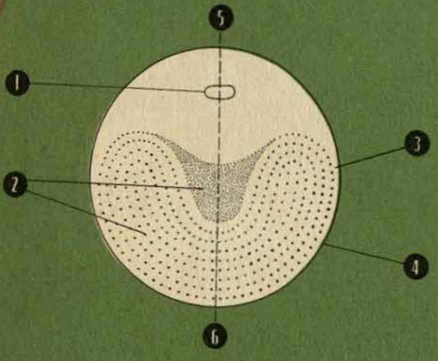


Placenta (detailed)
1. Uterine muscles. 2. Uterine capillaries. 3. Intervillous space. 4. Villus. 5. Foetal chorion.

maternal and foetal tissues, the main role of which is the transfer of substances between the mother and the embryo. I, 64; V, 57, mi.



Planaria (diagram of organs)
1. Eyes. 2. Head. 3. Intestine. 4. Mouth. 5. Pharynx. 6. Opening of pharynx. 7. Tail.



Poles, animal and vegetal (of amphibian egg)
1. Nucleus. 2. Yolk. 3. Cortex. 4. Vitelline membrane. 5. Animal pole. 6. Vegetal pole.

Plagiotrope: an organ in which the action of weight imposes a horizontal direction. III, 63, 64.

Plague: an infectious, contagious disease, of an epidemic nature, characterized by high fever, the appearance of pectoral and inguinal buboes, inflammation of the lungs, and haemorrhage of the mucosa. It is caused by Yersin's bacillus and is generally transmitted by the rat-flea. VI, 19, 23, 29; VII, 75, 78, 80.

Planaria: platyhelminth worms of the Turbellaria group, notable for their faculty of total regeneration, any part being capable of reconstituting a complete organism. I, 94-100; II, 14.

Plants (vascular and non-vascular): plants of the Cryptogamous, Thallophyte and Bryophyte groups, that do not possess vessels for the circulation of sap. They are the opposite to vascular plants, including the vascular Cryptogams and the Phanerogams, or flowering plants. III, 50.

Plants, with and without flowers: an essential distinction among plants in which the plant body is made of leafy stems (corms), between plants with concealed reproductive organs (plants without flowers), and plants with visible reproductive organs (plants with flowers). In plants without flowers (non-vascular Cryptogams, such as mosses, or vascular plants, such as ferns), the plant body may be alternately haploid (gametophyte) or diploid (sporophyte). The life cycle of these plants includes the alternation of sexual and asexual generations; eg, in mosses, haploid leafy plants carrying reproductive organs are succeeded after fertilization, by diploid sporophytes, stems without leaves carrying a capsule, the sporangium, in which are enclosed the spores: these, having undergone meiosis, are haploid cells and will again produce sexed haploid plants with leaves. On the other hand, in flowering plants (Phanerogams, Gymnosperms or Angiosperms), the life cycle is simplified: there is a concealed alternation of generations. All individuals are diploid; the gametophyte has become an evanescent tissue in the flower, which itself is only a differentiated leafed axis which bears and carries the reproductive organs (stamens and pistil). In flowering plants, the haploid phase is thus reduced to a few cell lines that give rise to male spores (pollen) and female gametes (ovules). Fertilization, produced inside the flower (whether hermaphrodite or separately sexed), gives a diploid individual. One of the remarkable characteristics of flowering plants is the double simultaneous fertilization that gives rise both to a normal ovum and a triploid ovum consisting of a male nucleus and a double female nucleus: the former will form the embryo, the latter will give rise to albumen, a reserve tissue for the growth of the embryo. The embryo and albumen constitute the seed which, by germination will give rise to a new plant. III, 13, 17, 49, 56-60, 61-67, 88.

Plasma: the liquid part of the blood, in which the pH is close to 7.2. It contains proteins, lipids, waste substances, glucose and salts. V, 21, 22, 23, 24, 35, 36, 37; VII, 26, 50, 51, 53.

Plasma membrane: a membrane delimiting the cytoplasm of any plant or animal cell endowed with selective permeability. The plasma membrane plays a fundamental part in metabolism of the cell. It is one of the most important factors in life. I, 46, 47, 48.

Plasmocyte: a variety of white cell, 7 to 20 microns in diameter and ovoid in shape, only found in the blood in a pathological condition characterized by an eccentric nucleus and a basophil protoplasm. VII, 34, 53.

Plasmocytosis: the appearance in the blood of plasmocytes in greater or lesser numbers during certain benign disorders (German measles) or malignant disorders (Kahler's disease). VII, 31.

Plasmodium (1): a mass of cytoplasm containing nuclei from the fusion of numerous cells or energids, eg, the plasmodia of Myxomycetes. III, 12, 48.

Plasmodium (2): a Protozoon, parasite of red blood cells, the cause of malaria. II, 49; IV, 125; VI, 42, 43, 45, 46.

Plasmolysis: a phenomenon produced when cytoplasm contracts round the nucleus, leaving an irregular interval between its periphery and the cellulose membrane of a plant cell. Plasmolysis is produced when the cell is deficient in water, the latter passing from the most concentrated to the least concentrated medium by osmosis. V, 43.

Plastids: characteristic elements of the plant cell. These are long filaments in which the chemical activity of the cell may be seen clearly. They are derived from chondriosomes of which they have the same lipoprotein nature. It is possible to distinguish leucoplastids, chloroplastids and chromoplastids. III, 16.

Platelets: see Thrombocytes.

Pleura: a serous membrane surrounding the lung. One of these membranes, the visceral pleura, covers the lung and conforms to its movements. The parietal pleura covers the visceral pleura and is attached to the thoracic wall. The space between the two layers of pleura usually contains a small quantity of liquid, which increases in volume during pleurisy. VII, 11.

Pleural effusion: the abnormal presence of fluid (serum or blood) in the pleura, produced by inflammation, injection, or an accident. Many forms of pleural effusion have been described: (1) depending on the nature of the fluid (serofibrinous pleurisy, haemorrhagic and purulent pleurisy); (2) according to the determining cause (rheumatic pleurisy, tubercular cancer, gangrene); (3) according to the seat and extension of the effusion (double pleurisy, diaphragmatic and interlobar pleurisy; (4) according to the condition of the person attacked (cardiac pleurisy). VII, 34.

Pleurisy: acute or chronic inflammation of the pleura, with or without fluid retention. VI, 27, 33.

Ploidy: the number of chromosomes in the cell. The cell is said to be diploid when each of its chromosomes is present in duplicate and haploid when each of them is single. IV, 33, 35.

Pneumoconiosis: a disease showing a deterioration of the lung parenchyma, produced by inhalation and fixation in the lung of very fine solid particles from the atmosphere (coal, silica or iron). VI, 62, 63.

Pneumococci: cocci in the form of a spear, generally coupled and surrounded by a capsule. They are the cause of pneumonia. VI, 18, 19, 51; VII, 34, 82, 85.

Pneumogastric nerve: see Vagus.

Pneumonia: inflammation of the lung parenchyma. Pneumonia is characterized by its etiology; (acute pneumonia caused by pneumococcus), by its pathological anatomy (unitary and massive localization, affecting segments rather than lobes, developing in a synchronous and homogeneous fashion) and by its clinical aspect, which is cyclical and spontaneously curable in a healthy person. Its prognosis is essentially conditioned by the form in which it appears. Antibiotics have completely transformed the prognosis of pneumonia in an affected person. VI, 23, 30, 33.

Pneumothorax, pathological: the existence of a gassy liquid in the pleural cavity, caused by a non-traumatic pleuropulmonary communication. At one time, it used to be caused by tuberculosis, but today spontaneous pneumothorax is most often due to a rupture of an emphysematous swelling. VII, 51.

Pneumothorax, therapeutic: insufflation of air or inert gas into the pleural cavity in order to collapse a lung mechanically, so as to permit treatment and cicatrization of the existing cavities. VI, 28.

Pneumotomy: an incision made in the lung to evacuate a site of infection. VI, 28.

Podzolization: grey soil derived from the prolonged transformation into 'podzol' that results from the erosion of the base of the primitive soil in temperate and rainy climates, with the formation in depth of a deposit or a concretion that includes oxide of iron. III, 122, 133.

Poikilothermy: a property characteristic of an animal in which the central temperature varies with the conditions of the external environment (fish, amphibia, reptiles and all invertebrates). The activity of these animals slows down, and may even stop completely, when a lowering of temperature occurs (hibernation of snakes and frogs).

Poison ivy: a plant frequently found in certain regions of North America, and with which simple contact produces dangerous burns on the skin. Its real name is *Rhus toxicondendron* and it contains an oleoresin that has marked sensitizing action. VII, 67.

Polarity: a property possessed in general by cells and living plant or animal organisms. Polarity consists of presenting two opposed poles, with a different physiological purpose, linked by a main axis. In a cell, polarity shows itself by a regular variation of certain properties along the axis (eg, the apico-basal gradient). III, 77.

Pole, animal: the protoplasmic portion of a telolecithal egg, from which come the polar bodies and where the germinal vesicle is to be found (a nucleus resulting from the fusion of two parental nuclei); it posesses the highest metabolic activity. It gives rise to the most anterior parts of the body. I, 127, 129, 131; mi.

Pole, vegetative: a region of the egg diametrically opposite to the animal pole, possessing the weakest metabolic activity and where the density of the yolk is highest. It generally gives rise to the endoderm. I, 127, 129, 131.

Pollen: in flowering plants, the microscopic grains produced by the stamens, which represent the male reproductive cells (gametes). II, 127-132; III, 64, 66, 68; mi.

Poliomyelitis: an infectious disease caused by a neurotropic virus that infects the anterior horns of the spinal cord. It is characterized by the appearance, after a few days, of fever and flaccid paralysis, localized in one or more muscle groups, which atrophy. The muscle localizations correspond to the cells of the anterior horns that have been destroyed. This disease is now being combated effectively by means of polio vaccine; this may be prepared either from killed virus or live attenuated virus. IV, 131; VI, 22, 23, 35-39; VII, 59.

Polyarthritis: simultaneous inflammation of a number of joints. This pathological symptom is frequently observed in acute rheumatic fever. VI, 32.

Polychaeta: a class of annelids characterized by the presence of numerous locomotory bristles. They are nearly all marine worms and are divided into two sub-classes: the free swimming and the sedentary polychaetes; eg, the common lugworm, well known to fishermen. II, 17, 18.

Polyembryony: in some animals, the natural separation of blastomeres (the first cells resulting from segmentation of the egg) that lead to the production of multiple embryos. Development of a number of embryos beginning with a single zygote (ovum). I, 111, 112; III, 17; mi.

Polyglobulia: an increase in the number of red cells; there are: (1) a secondary reaction polyglobulia, caused by cyanosis, altitude, or poisoning; (2) an essential primary polyglobulia: erythrocytosis or Vaquez's disease, a malignant illness that develops very slowly. VII, 31, 148.

Polymerization: formation of a chemical compound by the union of a number of identical molecules: eg, glycogen and starch are polymeres of glucose. III, 22, 23, 24; IV, 81, 83.

Polymorphism: a property possessed by certain species of having different forms; eg, the male and female in many animals are very different (sexual polymorphism). II, 44.

Polyneuritis: the simultaneous disorder of a number of nerves under the effect of an infectious disease (virus), or alcoholism, or acute deficiency of vitamin B (beri-beri). V, 52.

Polymorphonuclear cell: characteristic white cells with multilobed nuclei. There are (1) eosinophil polynuclear cells with a nucleus that is little lobed, the function of which is not well known; (2) neutrophil polymorphonuclear cells, representing 60% of the white cells; (3) basophil polymorphonuclear cells. IV, 112-115; V, 28, 31; VI, 52, 54, 131, 133; VII, 34, 53, 98.

Polynucleosis: an absolute or relative increase in the number of polymorphonuclear leucocytes in the blood. VII, 31.

Polyoma: a variety of cancer caused by a virus observed in different species. Its main characteristics are the number and histological diversity of the lesions produced in the same animal. IV, 100.

Polyploid: an organism in which, following an anomaly of cell division, the number of chromosomes, normally 2 n, is multiplied, either naturally, or experimentally, by two, three, or four. Many cultivated plants, whether ornamental (petunias and chrysanthemums) or useful (flax, beetroot and oats), are polyploid. III, 16, 129, 131, 132.

Polysaccharide: see Glucosides.

Polystomum: a form of Monogenea; a parasitic worm that inhabits the bladder of the frog in the adult state. II, 106.

Portal vein: this conducts to the liver all the venous blood of the visceral organs of the abdomen, with the exception of that of the kidneys. VII, 27.

Post-operative shock: the complex of cardio-respiratory and general manifestations, such as fall in blood pressure, acceleration of pulse, and grave collapse, that follow a marked call on the blood supply. Now the replacement of blood by perfusion during an operation has almost eliminated this complication, although in the past it was quite frequent. Modern parasurgical anaesthesia and resuscitation methods mean that operations can now be performed without danger, which until quite recently would have seemed impossible. VII, 118, 109, 124.

Posterior pituitary: see Pituitary.

Post-infection: a second infection caused by the same micro-organism. Usually, the organism produces antibodies that give it sufficient protection against this second infection, but the virus of influenza, may escape from this process of natural immunity by means of a modification of its biochemical structure. VI, 30.

Potassium: a metal present in the form of K^+ ions in the cytoplasm of cells. In all living beings it is essential for the maintenance of selective cell permeability. K^+ ions are present in strong concentration in the red cells of vertebrates and play an important part in the oxygenization of haemoglobin. On the other hand, when nerve impulses are conveyed and muscle contraction takes place, the escape of K^+ ions from the intracellular environment towards the extracellular environment determines the rapid depolarization of the membrane and the appearance of the action potential. I, 47; V, 41-47, 62-64.

Pott's disease: localized osseous tuberculosis of the spine, manifesting itself generally in the form of bone pain, a rounded spine, due to the disease attacking the vertebrae, and, at an advanced stage, paraplegia and cold tuberculous abscesses. Modern antibiotics, anti-tubercular substances and surgery (grafting) have transformed the prognosis of this disease. VII, 110.

Precipitin: an antibody substance that is formed in the serum of a patient following the introduction of an antigen. VI, 43.

Predator: an animal that attacks another, called prey, in order to feed on its tissues after having killed it. A predator is the opposite of a parasite, the larva of which will develop to the detriment of the tissues of another organism called the host, the death of which occurs only when the parasite has achieved its development. II, 154, 155.

Preformation: a theory, long disproved, according to which all the differentiations of the adult organism are represented in miniature in the ovum or the sperm, and that postulates that their development is only a simple enlargement. I, 26, 128, 131.

Preventive medicine: see Industrial medicine.

Primary infection: the initial episode of tuberculosis, characterized by a chancre of lung infection and mediastinal adenopathy and local lesions where the tubercle bacillus has penetrated. Synonym: primary tuberculosis. VI, 27.

Primates: plantigrade mammals whose thumbs are opposable to the other fingers (generally four) and the brain of which is highly developed. Man is the only one among these to live in all climates. Nearly all primates are social. They are divided into three sub-orders: the Lemuroids, the most primitive; the Tarioids, and the Anthropoids. II, 15, 20.

Primordium: a mass of plant cells that will develop into an organ, eg, a leaf, a root, or a flower. III, 16, 42, 43, 63.

Proaccelerin: one of the plasmatic factors of coagulation. Proaccelerin or the labile factor is rapidly destroyed in stored plasma. VI, 36.

Proconvertin (or factor VII): a plasmatic factor of coagulation. V, 136.

Prochordates (or protochordates): a grouping that includes *Amphioxus* and Tunicata (q.v.); the Prochordates possess a flexible dorsal notochord either throughout life or in the larva. IV, 10.

Progesterone (or luteal hormone): a hormone produced by the corpus luteum during the second half of the menstrual cycle. It causes morphological modification of the uterine wall, permitting nidation of the fertilized ovum. The secretion of progesterone takes place between the eighteenth and the twenty-sixth day of the cycle. I, 151; V, 57, 58, 59, 95; VI, 103; VII, 35.

Prolymphocyte: a young developing lymphocyte, at the intermediate stage between lymphoblast and lymphocyte. VII, 34.

Promonocyte: a young developing monocyte, at the intermediate stage between monoblast and monocyte. VII, 34.

Properdin: a certain blood protein which with the aid of complement and magnesium salts, has bactericidal activity. Its action is undoubted *in vitro*, and it seems that it works normally *in vivo* and therefore in the organism. IV, 108.

Prophage: an inactive, non-infectious form of a bacteriophage. Incorporated in the chromosome of the bacteria, the prophage is transmitted with the genes, like an hereditary character. This kind of symbiotic equilibrium of prophage and bacterium (called lysogeny) may end at any time, either under the influence of an inductive agent (x-ray and ultra-violet rays) or spontaneously: the prophage then becomes an active virus. IV, 108.

Prophase: the first phase of mitosis. This phase is characterized by a shortening and thickening of the already individualized chromosomes, by a dissolution of the nuclear membrane, and the formation of an acromatic spindle. I, 62, 63.

Prophylaxis. preventive treatment of a disease before it has developed in the organism. VI, 28, 31, 46, 47, 117; VII, 119.

Proprioceptor: a receptor nerve-ending sensitive to various changes that an organ or tissue may be subjected to. The best known example is the neuro-muscular spindle of striated muscles, which is stimulated by the lengthening of the muscle fibres themselves. II, 65; V, 159; VII, 61.

Prostate: a gland, shaped like a chestnut, which is located under the bladder, resting on the perineum. It is traversed by the urethra. It has two genital functions: its glands supply a diluting liquid for sperm, and during ejaculation its cavity is the site of a mixture of fluids that contribute to the making up of semen. I, 144; VII, 94.

Protandry, protogyny: terms used in plant biology relating to plants in which the sexes are not separated. In the case of protandry, the male sexual elements are mature before the female; in protogony it is the other way round. III, 66, 67.

Protanope: a person affected by an anomaly of vision so that he cannot see the colour red. This anomaly is due to the absence of certain pigments called 'erythrolabes' in the cones of the retina. V, 106, 109, 110.

Protein: complex substances generally in the form of a chain of a number of amino acids (eg, albumen and globulin). I, 37-39, 153, 154; III, 30; IV, 79, 81; VI, 48, 95, 109; VII, 17, 28.

Proteus: an amphibian living in the caves of Carniola, in Yugoslavia. *Proteus* has a long cylindrical body, about 20 to 30 cm long, with four limbs, lungs and gills. It is blind and without pigmentation. II, 37; V, 31; mi.

Prothrombin: this is formed in the liver under the effect of vitamin K. It is a glycoprotein of the blood and plays an important part in the coagulation of blood. Prothrombin is one of the essential factors in the formation of thrombin, a catalyst enzyme of the transformation of fibrinogen into fibrin. I, 153; V, 35, 36, 37, 52; VII, 28.

Prothrombinase: a synonym for thromboplastin. V, 36.

Protista: living unicellular organisms, either animal (Protozoa) or plants (Protophytes). I, 15, 20, 85; II, 49.

Protocaryotes: organisms in which the cell nuclei are still very imperfect, and therefore primitive, eg, bacteria (synonym: pseudocaryotes). III, 46.

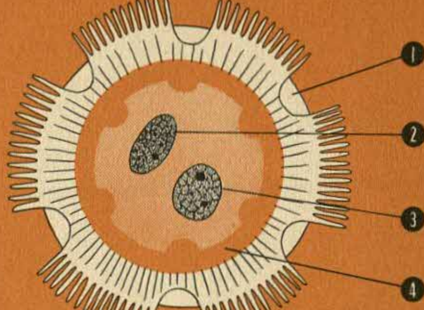
Protogyny: see Protandry.

Protopectin: a precurser substance from which a plant produces pectins. III, 69, 71.

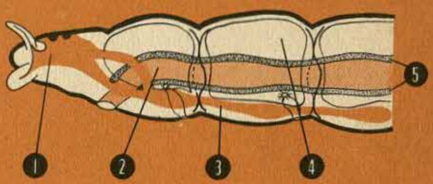
Protophytes: unicellular plants. II, 15.

Protoplasm: a fundamental part of all living cells, including the cytoplasm and the nucleus. I, 35, 37, 38, 66; III, 22, 23, 102; IV, 25, 26.

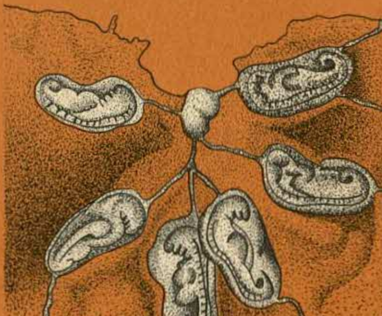
Protoplast: a bacterium that has been deprived of its cell wall and, under the effect of internal osmotic pressure, takes on a spherical shape. Only Gram-positive bacteria may be entirely deprived of their membrane, by means of the action of a hydrolizing enzyme, lysozyme. Gram-negative bacteria (eg, *Escherichia coli*) with a membrane of more complex chemical composition, may, under certain conditions (culture in a medium with the addition of penicillin) be transformed: these are then called spheroplasts. The protoplast, uncovered living matter, preserves a certain number of properties of the bacterium from which it came, namely, the ability to sporulate, and to conjugate, and its chemical composition, but it loses others: a protoplast cannot be invaded by a bacteriophage



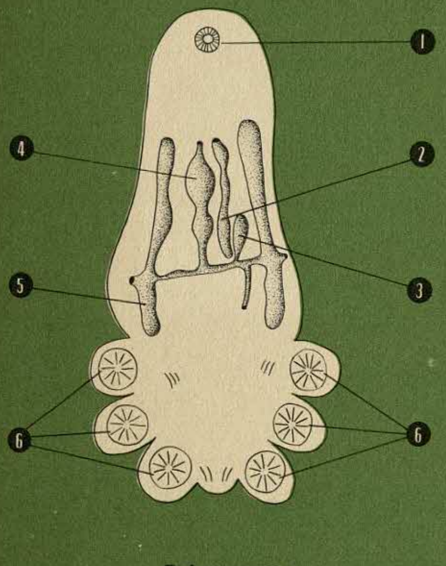
Pollen (Peach flower)
1. Pore. 2. Generative nucleus.
3. Vegetative nucleus. 4. Shell.



Polychaeta (section of anterior region)
1. Cerebral ganglia. 2. Digestive tract. 3. Nervous system. 4. Coelom. 5. Blood vessels.

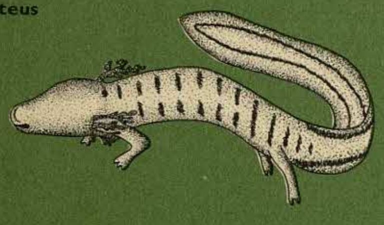


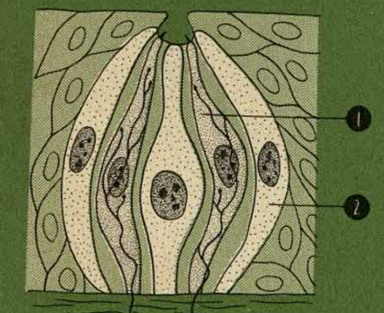
Polyembryony



Polystomum
1. Buccal sucker. 2. Testis. 3. Ovary. 4. Uterus. 5. Vitelline gland. 6. Ventral suckers.

Proteus





Receptors, taste (vertebrate)
1. Taste cells. 2. Supporting cells.

because it has lost the cell receptors on which the virus attaches itself. Apparently it cannot multiply. Protoplasts, in their physiological resemblances to and differences from whole bacteria, are an important field of study for biologists and geneticists. IV, 26, 46, 47, 48, 50.

Protopterus: a lung fish of central Africa. *Protopterus* is capable of surviving in the dry season by hollowing out a nest in the mud and surrounding itself by a mucous cocoon that protects it from desiccation. This form of resting, or aestivation, may last six months. II, 61.

Protozoa: animals formed of a single cell. *Amoeba* and *Paramecium* are interesting examples of unicellular animals. I, 85, 86; II, 112; IV, 112.

Provirus: a particular condition that a virus may take on and that precedes the condition normally assumed by viruses. IV, 21.

Proximal tube: that segment of the kidney tube that is closest to the glomerulus. V, 21, 22, 23.

Pseudocaryotes: see Protocaryotes.

Pseudomonas: microscopic organisms in the shape of rods, mobile and Gram-negative. One of the best-known organisms belonging to this genus is *Pseudomonas aeruginosa* (or pyocyanic bacillus), responsible for necrosis and suppuration (blue pus). IV, 47, 146, 147.

Pseudopodia: retractile and mobile elongations of protoplasm of very varied and changing shape, protruded in order to move and feed by certain cells like leucocytes or certain protists like *Amoeba*. I, 85.

Pseudotumour: an inflammatory tumefaction characterized by the presence of nodules formed by a network of mycelial filaments that are evacuated by fistules; they are due to a proliferation of a parasitic fungus. VI, 64, 65.

Psycho-analysis: the theory and technique of psychological treatment devised by the Viennese psychiatrist, Sigmund Freud (1856-1939). The theory of psycho-analysis gives great emphasis, both in normal psychology and in the genesis of neurosis and psychoneurosis, to infantile sexuality. This sexuality, or more generally a wider impulse called libido, is repressed by education and the parental environment and pushed by the individual into his unconscious, but it may nevertheless be expressed in socially acceptable forms, as in the creative arts and in dreams. Studies of infantile sexuality, carried out through the symbolic interpretation of dreams, by direct observation of behaviour, and especially by the study of language difficulties, indicate a number of stages through which the young infant passes, stages at which he takes pleasure in touching certain organs (the anal stage, the nasal stage, and the genital stage). The whole of the first period of infancy (up to five or six years) which is generally forgotten by the adult, is a period where sexual (not genital) desires are felt with intensity. It is then that the constellation of feelings that tie the young male infant to its mother (the 'Oedipus complex') is elaborated. Love for the mother has, during this period, a sexual character and the manner in which the infant will find this love accepted or repressed will influence it in a decisive manner in its adult sexual behaviour. This love for the mother is accompanied by sentiments of antagonism towards sisters and brothers and sentiments of hate or jealousy towards the father. These emotions towards the father are expressed in the form of the castration complex (the desire of the infant to castrate the father) and of the fear and anxiety of seeing himself going through the same treatment. It is only much later that the young male infant, by means of ambivalence in his emotions towards the father (both admiration and the desire to replace him), will form his personality by means of the superego. The development of the female infant implies a complicated detachment from maternal affection and a fixation on the father, which is called the 'Laodicean complex'.

From the methodological point of view, psycho-analysis examines every psychological phenomenon following three lines of approach: (1) 'dynamic', considering psychological development as the results of conflicts and combats (modern philosophy would employ here the terms of dialectics); (2) 'topical', which tries to determine the localization of a psychological phenomenon in the region of the preconscious, the subconscious and the conscious; (3) 'economic', which defines the energy of each of the psychological facts considered.

Therapeutic psycho-analytic technique is one of free association; the patient stretched out on a divan, speaks about himself. The psycho-analyst, placed behind him, observes the incidents that mark this monologue. A silence corresponds to 'resistance'; the relations of the patient and the psychiatrist lead to a certain number of 'transfers': the patient identifies the doctor with certain persons who have played an affective role during his infancy and he feels the same sentiments towards him. The psychiatrist uses this 'transfer' to surmount resistances and lead the patient to an awareness of the real origin of his difficulties. The psycho-analytic technique, at first used solely for the treatment of psychoneuroses, has gradually been extended to the treatment of neuroses, hysteria and paranoia. VI, 57, 152; VII, 43, 46, 47.

Psychobiology: the study of the close relationship between biology and psychology, a disorder in one always affecting the other to a varying degree. Treatment today must always take account of these facts. VI, 150-155, 156-157.

Psychochemistry: treatment of psychological and psychosomatic disturbances by means of chemical substances that tranquillize the regulatory centres at the base of the brain. These neuroleptic substances are known under the general term of tranquillizers or ataraxics, eg, chloropromazine. VII, 151.

Psychosomatic diseases: diseases characterized by an initial phase, a functional phase, a reversible phase, and a lesional irreversible phase; it is possible to go from one psychosomatic illness to another. VII, 42, 43, 46, 47, 62, 110.

Psychoprophylaxis: prevention of reactions that are harmful to the organism by means of a psychological preparation capable of suppressing them, modifying them, or creating certain conditioned reflexes (the psychoprophylaxis of delivery pain). VII, 64, 65.

Psychosurgery: a surgical method of dealing with the nerve centres of the brain in order to re-equilibrate the mentality and behaviour of the individual. Pyschosurgery consists in destroying or disconnecting parts of the frontal lobe, either by lobotomy (destroying or disconnecting the grey or white matter) or by leucotomy (section of the white matter). Lobotomy is a serious mutilating operation and is being replaced more and more by tranquillizers of a chemical nature (psychochemistry). VII, 138.

Psychotherapy: all methods of treatment based on psychology. There are very varied forms of psychotherapy, eg, psycho-analysis, narco-analysis, psycho-drama, and group therapy. VII, 43, 44, 46.

Psychrophil: an organism adapted to life at very low temperatures. IV, 74.

Pteridophytes: a synonym for vascular Cryptogams. II, 54; III, 52, 54, 57, 58.

Pulmonary arterial network: the surface of the fine arterioles and arterial capillaries of the blood in the lungs. V, 12, 13.

Pulmonary artery: an artery that starts from the right ventricle and conveys venous blood to the two lungs. V, 14; VII, 120.

Pulmonary heart, acute: a heart attack characterized by a sudden stoppage of blood flow in the pulmonary capillaries, caused, for example, by a large pulmonary embolism; this arrest causes circulatory stasis upstream which overloads the right heart and during this time the left heart is beating empty. This circulatory stasis shows itself by intense pain, the patient then has complete dyspnoea, rapidly becomes cyanotic, and finally collapses in syncope. Acute pulmonary heart, which also occurs during serious asthma crises, and after certain spontaneous cases of pneumothorax, requires urgent treatment. VII, 51.

Pulmonary oedema: a sudden flooding of the lung alveoli by blood plasma, which is an accident of great seriousness, necessitating urgent treatment. The most frequent cause is cardio-vascular: ie, left ventricular insufficiency, leading to circulatory stasis upstream in the lung capillaries. Acute oedema of the lung is manifested by dyspnoea with abundant frothy expectoration, of a salmon pink colour and the occurrence, on auscultation, of rustling râles at the bases of the lung cavities. VII, 51.

Pulsatile haematoma: an accumulation of blood leaked from an artery, which remains in communication with the latter. Continuing to receive the systolic blood pulse, it pulsates and progressively increases in size. It must therefore be operated on. VII, 136.

Pulse: the rhythmic pulsation of the blood in the arteries, easily perceived on the inside of the wrist or on the temples and corresponding to the rhythm of cardiac contractions (70 to 80 per minute). In cases of haemorrhage or stress (q.v.), the pulse is hardly perceptible, but during fever or tachycardia its rhythm may exceed 100 per minute. VI, VII passim.

Punctum proximum: the minimum distance of distinct vision. This point is situated at 7 cm in infants, and increases with age (25 cm at forty years) owing to the loss of accommodating power of the lens (presbyopia). V, 146.

Purine bases: bases that form part of nucleic acids. They are derived from purine and include adenine (the precursor of adenosine) and guanine. I, 49, 52.

Purpura: a lesion of the skin characterized by the escape of cells from the capillaries: it is a cutaneous haemorrhage. This lesion has given its name to a certain number of syndromes in which it is the principal phenomenon. V, 36, 37; VII, 99.

Pus: a pathological exudate of liquid consistency, coloured yellow and with a slight odour; it is filled with dead cells and large polynuclear leucocytes in very bad shape, most of which are disintegrating. IV, 113; VII, 38.

Pycnotic nucleus: a nucleus that has become homogeneous and stains equally throughout; a condition due to the death of the nucleus. VII, 35.

Pylorus: the exit orifice of the stomach, situated at the start of the duodenum. The pylorum is a frequent seat of cancers. V, 13.

Pyogens: bacteria that cause suppuration (streptococci, staphylococci and pyogenic bacteria). VII, 31.

Pyramidal cell: nerve cell found only in the cerebral cortex (grey matter of the cerebral hemispheres). V, 70, 73, 75, 77, 78, 80.

Pyridoxin: see Vitamin B_6.

Pyrimidine bases: chemical substances that enter into the composition of nucleic acids. Pyrimidine bases include cytosine, uracil and thymine. I, 49.

Pyruvic acid: chemical substance with three carbon atoms that plays a key role in metabolism. I, 43.

Pyuria: an emission of urine mixed with pus, caused by infection of the kidneys. VII, 34.

Q

Quantum: the minimum quantity of emitted or propagated energy. The quantum theory is due to the physicist M. Planck, and constitutes the application of the atomic theory to energy. By extension, the term is used in physiology to designate any discrete quantity of energy or matter that reacts on the sensory organs, eg, the quantum of light falling on the retina. This is sensitive to one or two quanta of light. V, 9, 67.

Quartan fever: a form of malaria caused by *Plasmodium malariae*. The bouts of fever are separated by two days without fever. This returns on the fourth day, counting from the day of the previous attack. VI, 43; VII, 86, 87.

Quick time: a test used in the laboratory to evaluate the rapidity of blood coagulation. V, 36.

Quincke's oedema: a variety of urticaria, characterized by the sudden appearance of oedematous infiltrations, limited and pruriginous, on the face and the mucosa. This disease develops in bursts over a period of years. It is considered to be an allergic manifestation and its danger lies in the possibility of the oedema being localized in the larynx. VII, 67, 70.

R

Rabies: a disease characterized by symptoms of excitation (spasm and convulsive fury) followed by signs of depression, (paralysis) ending in death. It is caused by a virus, transmitted by bites or wounds licked by an animal suffering from the disease. VI, 19, 22; VII, 79.

Rachis: a synonym for vertebral column.

Rachitis: see Rickets.

Radial symmetry: symmetry around an axis. It is found in most higher plants and among animals. The best examples are Coelentrates and Echoniderms, among which, after metamorphosis, it is superimposed on bilateral symmetry. I, 128, 131.

Radiation-dermatitis: a lesion caused by the application of x-rays to the skin, characterized by a red and tenacious cutaneous eruption. VII, 20.

Radiations: the emission of rays or particles. Radiations are used in medicine in a number of different fields, but their chief uses lie in the investigation of functions, the localization of lesions, and in radiotherapy. In the investigation of functions, x-rays are used (radioscopy and radiography). Early radiographs showed only the outlines of the skeleton and certain hollow organs (lungs), but today it is possible to explore also the deep parts of the organism by radiographing organs that are normally filled with liquid (gall bladder, kidneys, veins or arteries and heart) after they have been injected with substances with an iodine base which are opaque to x-rays. In this way it is possible to procure evidence, for example, of tumours or aneurisms in the brain. Therapy based on radiations (radio-therapy) aims to destroy some cells selectively, leaving neighbouring cells intact, and using for this purpose radioactive substances which, in decomposing, emit radiations (x, alpha, beta or gamma). Among the various chemical substances used (radium, gold, etc.), radioactive cobalt is now one of the most used. Radiotherapy is used in the treatment of most cancers (betatron). Sometimes, in order to increase the radio-sensitivity of the cancerous cells in relation to that of normal cells of the organisms, the patient is made to absorb a substance based on radioactive tritium. The amount of radiation given is extremely important; used in amounts that are too strong, or too small, or often repeated, radiations can cause profound disturbances (burns and cancers). VI, 134, 135; VII 20-22, 27, 92, 95-97, 100, 136-137.

Radicle: origin of the root of a small plant. III, 62.

Radioactive cobalt: cobalt obtained artificially, the radiation of which is used in the treatment of cancer. Cobalt contained in a bomb with a narrow opening, irradiates the cancerous zone destroying the malignant cells, which are more sensitive to such radiation than healthy tissue. II, 158; III, 133.

Radioactive isotopes: radioactive elements obtained artificially in nuclear reactors or in particle accelerators. Introduced in small quantity into the organism, either singly or as constituents of complex molecular structure, they behave exactly like an ordinary element, but their radioactivity, easily detectable, signals any movement and allows the normal destination of the element to be observed. Thus the duration of life of red cells has been determined by incorporating radioactive iron in haemoglobin; radioactive iodine has enabled us to elucidate the functions of the thyroid; and radioactive potassium, has enabled us to follow the exchanges that are produced through the membranes of the nerve cells at the moment of the transmission of impulses, etc. II, 110; V, 42, 43, 63, 135; VII, 22, 28, 137.

Radio-cardiography: radiography of the heart at different periods of its contraction, enabling this to be observed. Isotope radio cardiography, after injection of a radioactive substance, enables us to determine the existence or the absence of communication between the right and left parts of the heart. VII, 23.

Radio-cinematography: the study by cinematography of images obtained by radioscopy. By varying the speed of the film, it is possible to analyze more minutely anomalies that have not been noted through radioscopy. VII, 21.

Radiography: see Radiations.

Radiokymography: a method of radiographic observation, invented in Germany in 1911 by Goett and Rosenthal. It consists in passing a lead plate pierced with horizontal lines between the patient and the film. The heart and the large vessels show their pulsations directly on the film. VII, 21.

Radioscopy: a technique of observation with x-rays that shows movements of the thoratic wall and the darkening of the lung on expiration when it empties itself of air. If a very limited zone of a lung is not ventilated, its luminosity will remain unchanged. Radioscopy is largely used in medical detection (tuberculosis) and also for the observation of anatomical modifications of the lung, the pleura, and the mediastinum (heart and lymph glands), and to examine cardio-respiratory movement. VII, 24.

Radioscopy, televised: a technique in current use of identification of a lesion in which a dark room is no longer required. The diagnosis of disorders of the digestive tract, which are difficult to interpret, eg, in cases of ulcers, cancers of the stomach or colon, may be made directly from an image on a television screen. VII, 21, 22.

Radiotherapy: the use of radium radiation in the treatment of cancer tumours. VIII, 92.

Range of variation: in ecology, the possible range of morphological or functional modifications of individuals of a species in relation to their environment; for instance, the very different phenotypical aspects of the same plant at high and low altitudes. II, 54, 55.

Ranvier's node: the interruption at very short intervals of the myelin sheath along a nerve fibre. V, 64.

Rauwolfia serpentina: a plant of Indian origin from which is extracted reserpine, which is used in the treatment of high blood pressure and some nerve disorders. III,153; VII, 159.

Reanimation: see Resuscitation.

Receptor, gustatory: a sensory chemoreceptor cell that is sensitive to certain chemical substances that have a taste; it is situated on the surface of the tongue epithelium. IV, 71, 72; mi.

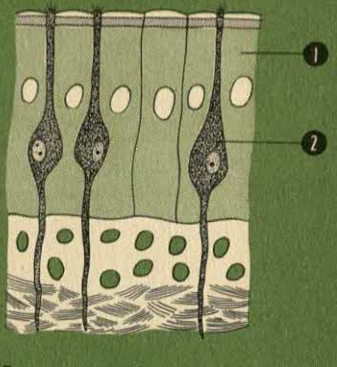
Receptor, olfactory: sensory cells that are sensitive to certain chemical substances that have a smell. In vertebrates, these cells are situated in the mucosa of the nasal fossae. In certain invertebrates (insects), they are situated on the distal parts of the limbs. II, 71, 72, 73; mi.

Recessive character (or factor): a hereditary factor which, although present in the genome, does not show itself morphologically or physiologically unless the organism that bears it is homozygous for this gene; that is to say, when it has received from its two parents the gene corresponding to this character. I, 115 et seq.; I, 122; III, 129, 130; VI, 115, 138, 139.

Recombination: the transfer of a gene of one bacterium to another by means of bacterial conjugation, that is to say, during the processes of bacterial sexuality. At a point on the surface of the two bacteria, a cytoplasmic bridge is established by means of which part of a chromosome of the donor (male) migrates towards the receiver (female). The chromosome fragment thus transferred, instead of being added to the genome of the receiver, is substituted for a part of this. IV, 34-36.

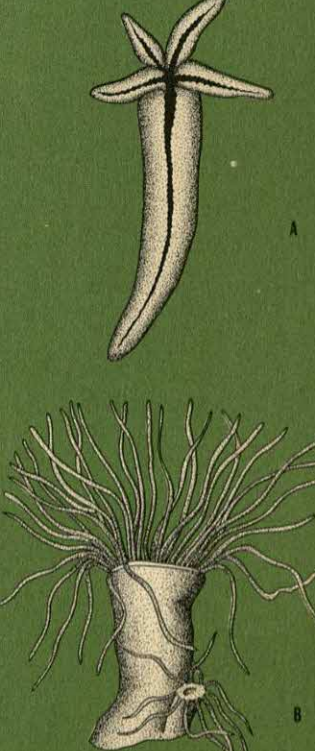
Red blood cell (or erythrocyte): a cellular element of the blood, the nucleus of which has disappeared and which forms a biconcave disc. Red cells are often piled up on one another. They contain haemoglobin, the role of which is to transport oxygen. They are formed in bone marrow and have an average count of five million per mm³ of blood. II, 90; V, 30, 31, 38, 39, 46, 134; VI, 29, 33, 42, 54, 78-80, 82, 89, 132, 134, 135; VII, 14, 31, 35, 53, 99.

Regeneration: the autonomous mechanism of repair in living organisms, by means of which parts that are lost or destroyed are reconstituted. Regeneration of a complete organ or of an important part of the body exists only in lower animals, eg, many invertebrates (hydra, planaria, starfish and worms) and some lower vertebrates (salamanders and lizards). In higher vertebrates the power of regeneration is restricted to the repair of tissues and the formation of scars left by burns and wounds, and this can be effected only by tissues that are capable of physiological regeneration; that is to say, those that are renewed continuously throughout life: such are, eg, the epithelia, connective tissue, bone tissue and blood cells, (in particular, the red cells, which are continually being renewed). Nerve cells are never renewable, although a cut nerve is capable of regeneration. The best known example of an animal with the power of regeneration is the planaria, a flat worm that can form an entire individual from a tiny fragment. Innumerable experiments have been made to elucidate the biological and chemical mechanism of its regeneration and it has been shown that the chief tissue responsible for this phenomenon is the mesenchyme, present in notable quantities in lower organisms and which, in higher vertebrates, is found only in the reticulo-endothelial system. The mesenchyme contains totipotent cells capable of transforming themselves into all sorts of specialized cells: thus in the planaria, regeneration of nerve tissue, of photosensitive organs (eyes), of pigment cells, etc. may occur. After amputation of any part of the body, a regeneration bud is generally formed and this morphological rearrangement corresponds to profound



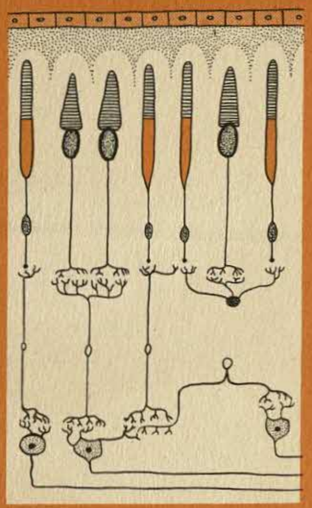
Receptors, olfactory (vertebrate)
1. Supporting cells. 2. Olfactory cells.

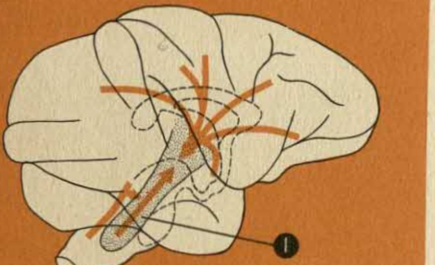
Red blood cell



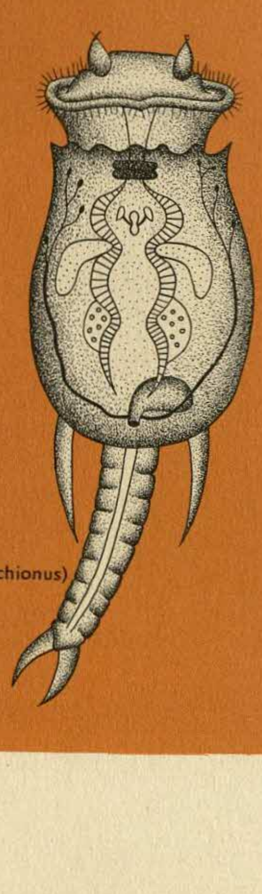
Regeneration
A. Normal physiological regeneration (starfish). B. Abnormal experimental regeneration (sea anemone).

Retina





Reticular formation
1. Reticular formation



Rotifera (female brachionus)

modifications of the general metabolism of the organism: the metabolism of proteins is especially disturbed and in animals with a circulatory apparatus a special alpha-globulin appears in the blood that accelerates the rate of renewal of the tissues. It would seem that in animals with a central nervous system nerve tissue plays a determining role in the normal reconstitution of an organ or an assembly of organs, as, eg, in embryonic development involving a succession of inductions in a chain. I, 27, 94-100; mi.

Renal colic: a syndrome that includes violent pain in the lumbar region which spreads towards the bladder and the back muscles, accompanied by constipation, vomiting and often bladder itching. It is due to the migration of a calculus or of a pus plug of the kidney towards the bladder through the ureter. VI, 94; VII, 156.

Renal pelvis: a funnel-shaped organ which covers the concave surface of the kidney. It collects urine from it and its continuation forms the ureter. VII, 21.

Renal tubule: part of the nephron connected to a Bowman's capsule. V, 21, 22.

Reproduction potential: the maximum number of offspring that could be produced in optimum conditions. II, 53, 54.

Reptiles: a class of lunged vertebrates, in which the heart separates venous blood from arterial blood imperfectly and the skin is scaly. Reptiles are poikilothermic. They are divided into four sub-classes: the Sauria (lizards and serpents), the Rhynchocephalia (*Hatteria*), Crocodilia and Chelonia (tortoises). IV, 18, 20.

Reserpine: an alkaloid extracted from *Rauwolfia serpentina*, used in medicine for the treatment of blood pressure and to tranquillize certain neuroses. VII, 149.

Residual air: the portion of air that remains in the lungs after forced expiration (on the average, 1.2 litres). V, 15; VII, 61.

Resolving power: measure of the efficiency of a microscope in terms of the smallest distance separating two distinct points visible through a microscope. I, 30.

Respiration: a fundamental biological process by means of which living organisms absorb oxygen and give off carbon dioxide. Anatomically, respiration is carried out by organs making possible the exchange of gases between the organism and the external environment. In animals, respiratory systems are varied, according to the conditions of life: invertebrate and vertebrate aquatic animals possess gills (annelids, crustacea, fish and salamanders). In insects, gaseous ventilation is carried out by a network of tracheae; in terrestrial vertebrates, gaseous exchanges are carried out in the alveoli of the lungs. Plants do not possess any differentiated respiratory apparatus. At the cellular level, respiration has the same characteristics in all living beings; it is the process by means of which each cell, using a fundamental substrate, glucose, gradually by small stages produces the energy required for the maintenance of the vital structures. Respiration consists therefore in a complex of chemical reactions, ie, a series of cellular oxidations that always proceed in the same order: breaking down of the glucose molecule into more simple carbon molecules; a complex metabolic cycle (Krebs'), at the end of which glucose is decomposed into carbon dioxide and hydrogen, which, after having been transferred on a chain of 'hydrogen transporters', unites with atmospheric oxygen absorbed in the respiratory system and is transported to the cells by the circulatory system. The complete chain of respiratory reactions constitutes catabolism. Oxidation in the cell occurs in the mitochondria and requires the intervention of numerous enzymes, among which are vitamins of the B group as well as other vitamins (C, E, and K). I, 43; III, 29, 30, 100; V, 12, 14-19; VII, 60-62.

Respiratory quotient: the ratio of the volume of carbon dioxide exhaled by the lungs to the volume of oxygen inhaled in the same time. The respiratory quotient (RQ) is generally slightly less than 1. V, 18, 19.

Resting potential: in a muscle or nerve cell, the value of the difference of potential that exists between the inside and the outside of the cell when it is resting. In a nerve cell, the negative resting potential is approximately 70 millivolts. V, 62.

Rest, winter: (botany) period during which the days are shorter than the nights. III, 118.

Resuscitation: this procedure aims to re-establish the equilibrium of the organism in the cardiovascular, respiratory, fluid, energetic and electrolytic systems. Resuscitation deals not with causes, but with effects inasmuch as these are non-specific. At first limited to the treatment of 'operation disease' (a term coined by J. Gosset for disturbances caused by surgical 'shock'), resuscitation has been extended to what J. Hamburger has called 'medical resuscitation'. It is the symptomatic treatment that aims to re-establish homoeostasis and to gain time to allow etiological treatment (dealing with the cause) the possibility of being effective. VII, 50.

Rete testis: a network of channels between the seminiferous tubules and the epididymis. I, 149.

Reticular activation: increase of activity of the nervous system, originating in the reticular formation. V, 82, 83, 85.

Reticular formation: a cellular formation extending from the lower part of the medulla oblongata to the upper part of the brain stem, formed by a network of small interconnected neurons constituting numerous relay paths. It plays a fundamental physiological role in the maintenance and control of awareness and is concerned with the appearance of fatigue. V, 82, 83, 87, 146, 147; mi.

Reticulo-endothelial system: a name given by Aschoff to cells, scattered in small groups in all parts of the organism (lymph nodes, bone marrow, spleen, liver, capillary walls) where the cells of the blood and lymph are formed and differentiated and which, although forming neither an organ nor a tissue, have a common origin (the mesenchyme) and common physiological properties, namely, phagocytosis, assimilation of iron and respiratory pigments (haemoglobin), the production of antibodies and the protection of the organism against infection. I, 48; V, 30; VI, 49; VII, 29.

Reticulo-histiocytiary system: special cells of the organism (reticulocytes and histiocytes) which play a fundamental part in the production of red cells. V, 30.

Retina: a photosensitive membrane, lining the internal wall of the eyeball, formed of light-receptive cells and numerous nerve cells. The light images that form on it cause stimulation which the retinal cells transform from photonic energy into nerve impulses that are transmitted to the brain by the optic nerves. I, 77; V, 78, 102, 110, 111; VII, 138; mi.

Retinol: see Vitamin A.

Reviviscence: the property of certain living organisms, animals or plants, of becoming active after having been desiccated and then dampened. (eg, the rotifera.) II, 59; IV, 59-62.

Rhesus factor: the Rhesus factor, so named because it was observed by K. Landsteiner and A. S. Wiener after injecting the blood of a Rhesus monkey into a rabbit's ear, thus producing an anti-Rhesus serum with which they studied the agglutination phenomena of human blood. The Rhesus factor, which is controlled by Mendelian genes, is an agglutinogen that is independent of the two A and B agglutinogens. It exists in the red cells of varying percentages of human beings (Rhesus positive blood) depending on their race and plays a role in certain mishaps of blood transfusion. Thus, when a Rhesus positive foetus fathered by a Rhesus positive father, develops in a female in whom the blood does not contain this factor (Rhesus negative), the anti-Rhesus agglutinins appear in the maternal blood, pass through the placenta, and agglutinate the red cells of the embryo: this causes haemolitic disease of the new-born. V, 39, 40.

Rhinencephalic amygdala: part of the rhinencephalon formed by an aggregate of nuclei. It is situated deep in the temporal region near the uncus. V, 87.

Rhinencephalon: nerve centres of the brain in vertebrates that are concerned with olfactory impressions. V, 86, 87, 90; mi.

Rhinitis: acute and chronic inflammation of the mucosa of the nasal fossae. VI, 54.

Rhizobium: a bacterium forming the nodules of the roots of leguminous plants that fix atmospheric nitrogen. IV, 32, 64, 71, 72.

Rhizoid: filaments resembling roots in algae and fungi. III, 48, 49.

Rhizome: a subterranean stem that usually develops horizontally and puts out 'leaf' forms seasonally. III, 49, 103, 116.

Rhizosphere: part of the soil situated in the immediate vicinity of plant roots. II, 15.

Rhodnius prolixus: a blood-sucking insect of Southern America, the *Rhodnius* is the intermediate host of the *Tripanosoma cruzi*, the vector of Chagas's disease. It has been used by V. B. Wigglesworth for his studies on metamorphosis and the part played by the juvenile hormone of insects. II, 45, 46.

Rhodomeloid: organized as in the red marine algae of the genus *Rhodomela*. III, 47, 48.

Rhodopsin: a chemical substance contained in the rods of the retina. It absorbs light radiation of a certain wave-length. Decomposition following this absorption supplies energy that sets off the visual nerve impulses. V, 102-104, 106, 110.

Rhopheocytosis: passage of a substance from one cell to another. The process of rhopheocytosis has been observed in stock cells of erythroblasts that capture ferritine molecules supplied by reticular cells. I, 47, 48.

Rheumatic fever: an infectious disease considered to be a complication of rhino-pharyngeal infection caused by a haemolytic streptococcus. It is characterized by a slight sore throat at first with fever, then an inflammatory disorder of the joints (acute polyarthritis, that is temporary and without sequelae), and organic manifestations that especially affect the heart (endocarditis and acute pericarditis). Rheumatic fever is responsible for most valvular heart diseases. Synonym: Boillaud disease. VI, 32, 34, 116; VII, 66, 156.

Rheumatism: acute and chronic disorders that have the common characteristic of pain localized especially at the joints and in the connective tissue that surrounds them. In a young person, acute rheumatic fever is serious because of the possibility of it affecting the heart. In an old person rheumatoid arthritis becomes chronic, painful and deforming, and is accompanied by ankylosis. VI, 114-116, 135.

Rhynchocephalia: a sub-class of reptiles that includes a single living specimen, *Tuatara*. I, 17; II, 27.

Ribonuclease: an enzyme that selectively attacks ribonucleic acid.

Ribonucleic acid (or RNA): see Nucleic acids.

Rickets: a deficiency disease, caused by insufficiency or absence of vitamin D and by insufficient exposure to sunlight. Rickets occurs during the period of growth in infants and is manifested by disturbances of bone formation (nodules or tumefactions of the bone joints) and by skeletal deformations (large head, thorax tapering out towards the base, deformation of the vertebral column and inflection of the diaphyses). These bone defects are accompanied by gastro-intestinal disturbances and general disturbance of health (anaemia, adenopathy, and muscular hypotonus). VII, 148.

Rickettsias: pathogenic micro-organisms intermediate between bacteria and viruses. They are responsible for numerous animal and human diseases inoculated by lice and causing exanthematic typhus. I, 135.

Rocky Mountain spotted fever: a disease observed in the Rocky Mountains and in India, caused by *Rickettsia rickettsi*, transmitted to man by a tick. This disease is characterized by a sudden onset of fever (40°C) with prostration and by an eruption of small lenticular red spots, lasting from the second to the fifth day. Mortality from this disease is still very high. VII, 86.

Rods (of retina): photosensitive cells of the retina, containing rhodopsin. In man and certain mammals (cats), rod cells are responsible for vision under poor lighting conditions. V, 102-4, 106.

Root system: all the roots of a plant, whether near to or far from its base, which they supply with water. III, 124.

Rorschach test: a psychological method of testing, based on the interpretation, by the person being tested, of designs formed of symmetrical blots obtained by folding a piece of paper on which a few blobs of ink have been placed, either of a single colour or several different colours. This method makes possible an assessment of intelligence, attention, memory and especially the emotional condition of the person being examined. VII, 43.

Rotation of the egg: an important series of pheneomena that takes place (in approximately one hour and ten minutes in the frog) after fertilization in the plane of bilateral symmetry of the egg. It consists of a reorganisation of the egg which results in its primary vertical axis being put into an oblique position. It is not a question of a mass rotation of the egg, but only of the cortical layer, which is displaced in relation to the deeper parts. It leads, through displacement of the cortical pigment, to the formation of the grey crescent that indicates the future dorsal side of the embryo. I, 131, 132.

Rotifera: microscopic multicellular aquatic animals; their name comes from the ciliary apparatus that covers their anterior extremity. The rotifers have been the subject of remarkable experiments on their ability to encyst and to revivify. I, 12, 14; II, 59-62; IV, 17, 59, 60 et seq.

Rust: see Uredineae.

S

Sacculina: a rhizocephalan crustacean, a parasite of crabs which at the adult stage is fastened like a pocket on to the abdomen of the host. I, 90; mi.

Salinization: formation of soils of saline type, rich not only in sodium chloride, but in carbonates, etc. III, 123.

Salivary glands: glands near the cavity of the mouth that secrete saliva. Salivary glands are in three pairs, the parotids, the submaxillaries, and the sublinguals. Each type secretes a different saliva which plays a mechanical role (formation of food mash) and a chemical one (the action of amylase hydrolyzing starches). I, 50, 52; VI, 120; mi.

Salmonellosis: diseases such as typhoid fever and paratyphoid fevers caused by ciliary bacilli belonging to the genus *Salmonella*. VI, 14; VII, 31.

Saprophyte: a non-autotrophic plant organism devoid of chlorophyll, and therefore unable to perform photo-synthesis, that feeds on decomposing organic matter. Saprophytes are opposed on the one hand to autotrophic plants that feed on simple mineral elements (carbon dioxide, water, nitrates and nitrites) and on the other, to parasitic plants that live at the expense of other living plants. A certain number of fungi are saprophytes (moulds, toadstools and mushrooms). Others are, according to circumstances, either saprophytes or parasites (eg, *Candida albicans*, which becomes a parasite in the intestinal mucosa of man). The same applies to certain microbes; those of tetanus, and of gangrene, for example, which are saprophytes in the soil and pathogenic in deep wounds. III, 11, 12, 68; VI, 18, 64, 65.

Sarcoma: a cancerous tumour of connective tissue. VI, 121.

Scar: see Cicatrization.

Scarlet fever (scarlatina): an eruptive fever caused by haemolytic streptococcus and characterized by a sore throat with congestion of the mucosa of the mouth and throat, and a fever at 40°C, then twenty-four hours later, a generalized eruption of large flat scarlet spots. VI, 19, 22.

Schick reaction: an intradermal reaction test carried out with diphtheria toxin. The Schick test is positive in persons who have practically no diphtheria anti-toxin in them. On the other hand, it shows as negative, with a few exceptions, in anyone who has been successfully vaccinated with the specific toxoid. During an epidemic it enables prophylactic injection to be limited to positive cases only. VII, 81.

Schistosoma: see Bilharziasis.

Schizogony: a phase of asexual multiplication of protozoa, including parasites living in cells or animal tissues and especially causing malaria in man. I, 111; VI, 42, 43.

Schizometamerism: a method of reproduction by means of which an animal becomes fragmented and separated from one or more segments (metameres) which later give rise to a complete individual. Schizogamy is seen in the polychaete and oligochaete annelids (*Lumbriculus, Dobecaceria caulleryi*). I, 111,

Schizophytes: a group that includes bacteria and the more simple Algae (blue Algae). III, 52, 54.

Sciatica: see Neuralgia.

Sclerophyll forest: a forest that has trees with hard, thick leaves, ie, adapted to dry conditions. III, 121-123.

Sclerosis: pathological hardening of a tissue. VI, 58, 83.

Scurvy: a disease characterized by multiple haemorrhage, especially of the gums, gastro-intestinal disturbances, and loss of teeth. Scurvy is caused by insufficiency or absence of Vitamin C in the diet. VI, 14, 109.

Sea urchin: a spheroidal echinoderm with a body almost completely covered with mobile prickles. Sea urchins possess radial symmetry in the adult. I, 93, 154, 155; II, 24, 25, 70.

Seed scarification: the scratching of the integuments of a seed in order to rehydrate the latter and accelerate germination. III, 62.

Segmentation: in embryology, cleavage or division of the egg. Segmentation of the egg leads to the formation of 2, 4, 8, 16, 32, etc., blastomeres and finally to the blastula. In anatomy, the linear repetition of similar parts is metameric segmentation. I, 127, mi.

Self-fertilization: a synonym for autogamy. III, 67, 131.

Seminal vesicles: glands near the testis formed by a sub-division of the posterior part of the Wolffian canals. I, 146, 150.

Seminiferous tubule: a small canal in the body of the testis inside which the spermatozoa are formed. The tubule is lined by spermatogonia and Sertoli cells which have an accessory supporting and especially a nutritive function. The spermatozoa develop while being displaced from the wall to the centre of the tubule (spermatogenesis).

Sensory cell: cells of peripheral receptor organs; these cells can transform a nervous impulse in a physical stimulus (influx) that is transmitted to the higher nerve centres. They are transducers of energy. Examples of sensory cells are visual cells (cones and rods), auditory, olfactory and tactile cells. II, 65.

Sepal: in the flower, the part of the perianth inserted on the floral receptacle, forming the calyx. Sepals may be free or fused, absent or constant in number, according to the genus and class of plant. III, 49.

Septal area: a formation in the visceral brain, situated above the olfactory gyrus and under the anterior part of the corpus callosum. It includes the gyrus sub-callosus (paraterminal body) and septum. V, 88.

Septicaemia: a permanent invasion of the blood by pathogenic germs. This disorder is always serious, although the prognosis of it has been transformed by the discovery of antibiotics. VI, 19, 23, 30, 79.

Septum pellucidum: a median structure formed from the base of the fore-brain. The septum, well developed in lower mammals, contains important nerve centres in relation to the hippocampus. V, 88.

Serology: the study of the immunizing properties of sera. I, 125; IV, 96, 97, 106, 110.

Serotherapy: the therapeutic use of sera: (1) human blood (in convalescence for certain illnesses) used as a protection against certain infectious diseases (eg, whooping cough); (2) serum (q.v.) from animals vaccinated against certain infectious diseases. II, 132; VII, 82.

Serotonin: a substance produced by the blood platelets, the gastro-intestinal mucosa and the brain. It is a vasconstrictor. VI, 50.

Serratia marcescens: an organism characterized by the beautiful red pigment that it contains; for which reason it is also called *Bacillus prodigiosus*. II, 15, 56, 57, 70.

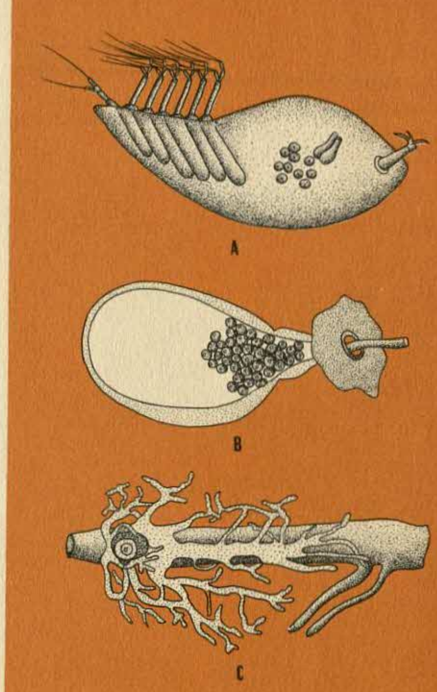
Sertoli cells: in vertebrates, cells of the wall of the seminiferous tubules, between which are developed the sexual cells which give rise to spermatozoa; the Sertoli cells play a supporting role and provide nourishment to these germinal cells. I, 145, 146.

Serum: a transparent liquid that separates from the blood cells after coagulation of blood. Serum has the same chemical composition as plasma, but does not contain fibrinogen. The serum of certain animals (eg, the horse) is used after they have been immunized against a number of pathogenic diseases (diphtheria, tetanus and plague): the sera thus prepared are called antitoxic sera. II, 116, 117, 152, 153; VII, 79, 82.

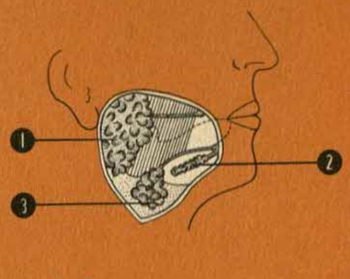
Sex ratio: the numerical proportion of the sexes in a given number of births, eg, the number of males per hundred females: cat, 107; mouse, 105; man, 104; sheep, 98. I, 112, 113.

Sexual differentiation: a process by which an embryo acquires the morphological characters of its own sex. The embryo of a vertebrate, at the beginning of its development, possesses a double assortment of genital ducts, the Mullerian ducts with feminine potentialities and the Wolffian ducts with male potentialities. According to the genetic sex of the embryo, one of these two structures will disappear and the genital organs will differentiate into male or female. This differentiation is dependent on special hormones secreted by the sexual glands of the embryo. I, 144-148.

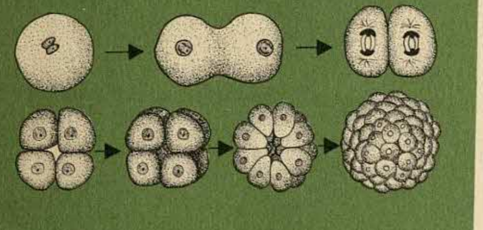
Sex gland: in animals with sexual reproduction, the organ or reproduction (ovary or testis) that produces the reproductive cells: ova or spermatozoa. In mammals, the ovary contains the ova, surrounded by a ring of nutritive cells called the Graafian follicle; the testis contains the seminiferous



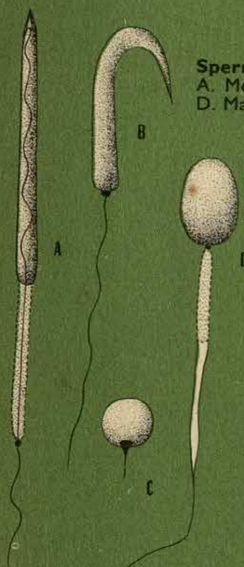
Sacculina
A. Free larval form. B. Beginning to attach itself to the crab's intestine. C. Parasitic adult stage. ramifying innumerable branches.



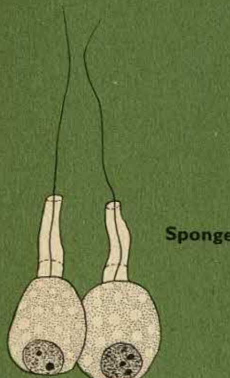
Salivary glands
1. Parotid gland. 2. Submaxillary gland. 3. Sublingual gland.



Segmentation



Spermatozoon
A. Mollusc. B. Rat. C. Termite. D. Man.



Sponge (choanocytes)

tubules (with spermatozoa and nutritive cells, ie, the Sertoli cells), embedded in the interstitial gland. Sex glands, apart from the function of reproduction, manufacture hormones that determine secondary sexual characteristics: in the male, testosterone, produced by the interstitial gland of the testis; in the female, folliculine, corresponding to testosterone, and progesterone, the role of which is to prepare for gestation. VI, 103, 120.

Sex hormones: chemical substances secreted by the genital glands: they are derivatives of cholesterol. They include the ovarian hormones, the main ones being steroids with 8 carbon atoms (belonging to the oestrone and oestradiol group) and the hormones of the corpus luteum of the ovary (steroids with 21 carbon atoms) or progesterone; the oestrogens, which cause the development of the female genital tract, and progesterone that acts on the uterus to allow the nidation of the ovum; the male hormones or androgen (steroids with 19 carbon atoms), the main one being testosterone, secreted by the interstitial tissue of the testis and exercising control on the morphological and functional development of the male genital tract. I, 113, 146, 147, 148, 149, 151; V, 57-59; VI, 103.

Sexual lability: a physiological property that allows an embryo during the process of development to differentiate into either a male or a female. I, 112, 113.

Sexuality: all the different methods of sexual reproduction adopted by living beings in order to ensure the survival of the species. Sexuality, in plants as well as animals, offers an extraordinary variety of forms and methods, but under this apparent diversity it may always be reduced to the union of two gametes of different sexes. The gametes may come from the same cell, as in some Protista (Foraminifera and Heliozoa) which has divided into two and of which the halves, after a rearrangement of the nucleus, fuse to give a new individual; this is autogamy, a phenomenon also observed in some plants, in which pollen and ovules belong to the same flower. But in most plants, and in all cases of multicellular animals, sexual reproduction is produced by allogamy, that is, by the fusion of two gametes coming from two different individuals, one male, the other female; this is fertilization; sometimes it is the result of conjugation (paramecia). Sexuality therefore implies in most cases the existence of dimorphism, resulting from morphological and physiological differentiations (secondary sexual characters) that are more or less marked. These morphological differentiations, as well as a number of other signals (olfactory, for example, in moths and auditory in crickets), are a means of sexual stimulation for the individuals of the other sex. The profound significance of sexuality is that it is less a means of reproduction than a process of genetic reshuffling. By means of exchanges of genes (segregation and crossing-over) that take place at the formation of gametes during meiosis, the individuals that are produced by fertilization are never absolutely identical with their parents, and it is this rejuvenation of the germen that avoids, in living beings, the accumulation of deleterious characters and extinction. One of the best proofs of this is that even in species that usually reproduce by asexual multiplication (budding, cell division, fission), or parthenogenesis (eg, in *Daphnia*) processes of sexual reproduction appear from time to time. I, 27; II, 49-52; III, 56-67; IV, 18, 19, 30, 36.

Shunt: in pathology, communication between two vascular cavities which normally are not connected. VII, 119, 122.

Sickle-cell: an hereditary disease in which the red cells are in the form of a crescent or a sickle. These abnormal red cells may produce serious anaemia that is often fatal. Sickle-cell, propagated by consanguineous marriages, mainly affect certain Negro tribes of Equatorial Africa. IV, 123; VI, 82.

Sigillaria: a carboniferous fossil tree that is found in oil-bearing strata. III, 49.

Silicosis: a disorder due to action on the lung of dust of silicon dioxide absorbed by inhalation. It is an occupational disease among miners or those in contact with fine dust from sand (foundry workers). VI, 14, 61, 62, 63, 67, 69, 70.

Silver fish: see Lepisma.

Sinus venosus sclerae (Schlemm's canal): a small circular canal, hollowed out in the sclera, surrounding the sclerocorneal junction, which ensures the evacuation of the aqueous humour. VI, 142.

Sinusitis: acute or chronic inflammation of the mucosa of the sinuses of the head. VI, 54.

Siphonales: an order of Xanthophyceae algae. III, 57.

Siphons: filaments or vesicles forming the bodies of algae and fungi, when they are not sub-divided into cells. III, 47, 48, 49.

Skin test: a method of distinguishing lesions of allergic origin. It consists in applying to the skin after scarification, or injecting interadermally, a small quantity of the substance that may be causing the allergy. The reaction, when it is positive, ie, when the person is allergic to the substance concerned, is shown by the appearance of a swollen papule, surrounded by a red halo that resembles a wasp sting. This reaction appears in most cases fifteen to twenty minutes after the inoculation of the allergen, but sometimes not until a day or two days later. In the case of skin sensitization by contact with a natural or synthetic chemical substance, skin tests are carried out that consist in applying the substance to the intact skin or skin that has been slightly scratched. VII, 71.

Sleeping sickness: an infectious disease, caused by the bite of a tsetse fly or *Glossina*. The parasite responsible is a protozoon, a trypanosome. The disease develops in two phases: the first is characterized by cervical adenopathies, erythematous patches and nervous disturbances; in the second phase the patient suffers from headache, apathy and, especially, attacks of sleepiness, which becomes more and more prolonged and if left untreated lead to death. VII, 71.

Slipped disc: an abnormal protrusion of the intervertebral disc in the spinal column. This hernia is most often at the level of the fourth or fifth lumbar vertebrae and causes compression of the roots of the sciatic nerve; it is accompanied by an acute pain in this nerve. VII, 105.

Smallpox: an infectious disease, epidemic and contagious, caused by a virus and characterized by a pustular eruption of a particular appearance that leaves scars. The haemorrhagic form leads to death in a few days. Jennerian vaccination is the inoculation of man with vaccinia (an infectious viral disease that affects horses and cows) in order to immunize him against smallpox (cross-immunity). VI, 19, 22, 23, 29.

Smears: preparations used in bacteriology and haematology, made by spreading on a small glass slide a drop of liquid for examination (bacterial culture, normal blood or pathological blood). V, 28; VI, 133; VII, 11, 36.

Sodium: a metal existing in the form of Na$^+$ ions in the majority of living organisms. The source of sodium in the organism is sodium chloride in food. The human organism contains 0.15% of sodium. The equilibrium of this element in the organism is maintained by a hormone, aldosterone from the adrenal cortex. This stimulates reabsorption of sodium in the renal tubules. Sodium plays an important part in the generation of nerve impulses. It is more concentrated outside than inside the axon during the resting phase, but passes in quantity through the exoplasmic membrane at the moment the action potential occurs and penetrates into the axone. Neurophysiologists have postulated the existence of a mechanism that eliminates sodium after the passage of these impulses. This mechanism has been called 'the sodium pump'. Medically, the sodium ion plays an important part in the equilibrium of water balance; retention during the course of renal disorders are the origin of oedemas. V, 23, 24, 62-64; VII, 26, 50.

Sol (or suspensoid): a colloid in a fluid state. I, 38.

Soma: the non-sexual cells of an organism, as distinct from the cells concerned with reproduction (germen). I, 91, 102, 151.

Somatic antigen: a microbial antigen on the body of the microbial germ. VII, 81.

Somatic heredity: the transmission of specific characters by cells other than germinal cells. This is the mechanism of hereditary transmission in asexual reproduction: the new organism is not formed by development from an egg, but by budding of the body or soma (eg, the fresh-water hydra). I, 107, 108.

Somatoblast: among the blastomeres, a cell destined to form the soma, as distinct from cells that will give rise to sexual cells (germen). I, 110.

Somatocytes: cells of the soma derived from somatoblasts. I, 107.

Somatogamy: in Basidiomycete fungi, the union of two cells of the soma following a fusion of mycelial filaments of different sex. III, 58, 59.

Somatopleur: in embryology, the external layer of the mesoderm. At the time of the formation of the coelom or general body cavity, the somatopleur underlies the ectoderm. IV, 17.

Somites: in the embryo, after neurulation, small blocks formed by the mesoderm on both sides of the notochord; they give rise to the muscles of the trunk and the axial skeleton. I, 135.

Spasm: an involuntary contraction of a muscle fibre. This term is employed most often when the smooth muscles contract (biliary, urinary, digestive tract or bronchial muscles). VII, 64, 65.

Spasmolytic medication: medication that suppresses spasmodic conditions. VII, 64, 65.

Spermatid: a sexual cell derived from a spermatocyte, giving rise by spermiogenesis to a spermatozoon (see Spermatogenesis). I, 117, 122.

Spermatogenesis: the differentiation of spermatozoa. The first elements that give rise to the gonads in a young embryo are the large clear cells called primary gonocytes which, in the male line, produce smaller cells, the spermatogonia. These multiply and grow, to give rise to the first order spermatocytes. Each spermatocyte undergoes meiosis, which reduces by half the number of chromosomes and transforms itself into two second order spermatocytes; each resulting spermatocyte then divides into two spermatids. Each spermatid then changes into a spermatozoon. I, 117, 122; VII, 90.

Spermatophore: a capsule enclosing the spermatozoa; found in certain insects, in cuttlefish and in annelids. II, 52.

Spermatozoon: a male gamete resulting from the development of the spermatid in the last stage of spermatogenesis or gametogenesis. In plants, the spermatozoon corresponds to the antherozooid. I, 112; II, 52; VII, 90.

Spermiogenesis: the development of the spermatozoon from the spermatid.

Sphagnum: moss that is the main source of peat. III, 116.

Spherophorus necrophorus: a microorganism that causes a disease in pigs and cattle (lesions of the hooves, dermatitis and necrosis of the skin and lips, abscess of the brain, lesions of the stomach, etc.).

It does not appear to be dangerous to man. It appears in the form of small bacilli (1 micron wide) of very variable length (up to 100 microns). IV, 41, 44.

Spikes: nerve impulses showing on the tracings as marked points resulting from the excitation of the nerve cell. Spikes are the graphic representation of the action potential. V, 98, 129.

Spiramycin: a new antibiotic isolated from *Streptomyces ambofaciens;* it is particularly efficacious in Gram-positive infections (staphylococcus, streptococcus, pneumococcus and enterococcus) and especially in respiratory infections. It is also active in the treatment of gonococcus infections, against treponema (syphilis), and against amoebiasis. VII, 87.

Spirochaetosis: a disease characterized by a reddish jaundice that may also show meningeal or renal symptoms. It is caused by *Leptospira icterohaemorrhagiae,* a spiral Protozoon with a small body, a common parasite of the rat, which transmits it to man by biting or through its excrement. VI, 70.

Spirography: recording by means of a closed-circuit respiration apparatus (spirometer) of the respiratory functions (consumption of oxygen and elimination of carbon dioxide). It enables studies to be made of the resting condition, vital capacity, and maximal expiratory volume per second (MEVS). VII, 24.

Spirometer (or spirograph): an apparatus used for the study of lung ventilation and, in particular, the recording of the value of the amount of basal metabolism by measuring oxygen consumption. VII, 24, 25.

Splanchnopleur: in embryology, the internal layer of the mesoderm. When the coelom appears, the splanchnopleur wraps round the endoderm. IV, 17.

Splenoportography: a method of observation that consists in taking a series of radiographs after injecting into the spleen a liquid that is opaque to x-rays. This liquid fills the splenic vein and then the portal vein and the intrahepatic veins. This technique enables an obstacle to be located on the venous path and also makes it possible to form an estimate of collateral circulation. VII, 27, 28.

Sponges: a group of pluricellular animals, the organism of which is very rudimentary and essentially formed of a digestive sac and either a siliceous or a shell-like skeleton. Sponges are the most primitive pluricellular beings in the animal world. Although certain of their cells are differentiated (choanocytes, germinal cells and contractile cells), these organisms do not possess any true tissue, nor, consequently, any organs. I, 86, 87; II, 14, 16, 17; VII, 28.

Spontaneous generation: the formation of a living organism that has come from another living organism. Pasteur showed that in nature spontaneous generation is not to be observed; but the problem of the synthesis of living forms is still open. I, 20, 22; II, 22.

Sporangium: a kind of sac in ferns and mosses, developed on leaves (sporophylls) containing spores. III, 49.

Spore: a diploid cell that constitutes the element of dissemination and reproduction in some bacteria and plants, in particular, plants without flowers (ferns, mossess, and fungi). III, 46, 47; VI, 64; mi.

Sporocysts: vesicles in which the spores of algae and fungi are formed. III, 47.

Sporophyte: in plant biology, applied to a diploid individual on which are formed spores in plants without flowers and seeds in plants with flowers. III, 48, 49, 57.

Sporulation: a property possessed by some bacteria of secreting around them a resistant shell or cyst. In the form of spores these bacteria can survive a long time, even if placed in an unsuitable environment. They may also resist extremely adverse conditions. II, 156, 158; III, 58; IV, 52.

Stamen: the male sexual organ of a flower, in which pollen is produced. The stamen is formed of a thin stalk supporting a sac (anther) composed of one or more cavities that contain the pollen. III, 13, 49, 63, 64, 66; mi.

Staphylococcus: a generic name given to bacteria that have a rounded form (cocci) characterized by their grouping, recalling that of bunches of grapes. As this microbe leads to the formation of pus, it has been given the name of pyogenous staphylococcus. It shows itself in a number of varieties which may be distinguished after their staining in an agar culture (aureus, citreus and albus). They cause furuncles and boils and may invade the blood (septicaemia caused by staphylococci). They may become localized in certain organs or around them (perinephritic phlegmon). In children they sometimes cause lesions of the lung. Staphylococcus has become resistant to many antibiotics. IV, 64, 65, 114; VI, 18, 19, 22, 30, 51, 55, 56, 93; VII, 34, 83-85, 87, 104.

Starch: a chemical substance that serves as a form of storage of polysaccharides in plants. Starch is to be found mainly in seeds and tubers. III, 27, 74.

Starling's law: a principle according to which, when the pressure and quantity of blood increase in the heart, the heart dilates and this physiological reaction releases the contractile force required to propel into the aorta the total amount of blood received. This law expresses the relationship between the dilatation of the heart and the force of its contraction. VII, 60.

Statidensigraphy: a method of recording moving radioscopic shadows that makes use of photoelectric cells and photomultipliers sensitive to x-rays. This method makes possible the recording of the 'lung pulse' in man; that is to say, the distention and rhythmic contraction of the diameter of the lung arterioles on the periphery of the lung, which are normally not observable. VII, 22, 24.

Steady state: a system is in a steady state when it appears to be stable, although its constituent elements are in continual movement, any addition of a new element being compensated for by the loss of an equivalent element. I, 74.

Stereoradiography: a process of dissociation of the superimpositions of images by radiography in relief. Two radiographs are taken of the same region by separating the two sources of rays by at least 7 cm; this difference corresponds to the average separation of the eyes. Under these conditions, it is possible to examine the two photographs, by means of special stereoscopic devices and to obtain a very clear impression of relief. VII, 21.

Stereotaxy: a current technique of brain surgery, used in order to reach, interrupt, or destroy a structure of small dimensions situated deep in the brain. Methods are used that permit the introduction of needles, electrodes and instruments of small dimensions, through a minute trepaned opening and with great precision and little damage. VII, 136, 138.

Stereotropism: the tendency to hide in fissures or in very isolated zones. II, 55, 56.

Sternite: a ventral plate of the integument of insects. II, 62.

Steroids: the substances derived from sterols. The main steroids are biliary salts and the steroid hormones (progesterone, deoxycorticosterone and corticosterone, cortisone, androsterone and testosterone). V, 52, 54, 57, 140; VI, 32, 90: VII, 14.

Sterol: polycyclic alcohol very common in living cells; sterols are found in animals (cholesterol and derivatives called steroids) and in plants (ergosterol). VII, 68.

Sthenic: in opposition to asthenia, referring to a condition of energy and activity. VII, 60, 61.

Stickleback: a fish common in fresh water. The male constructs a nest in which, after a nuptial dance, the female comes to lay her eggs. It is in observing the behaviour of the male stickleback at the moment of the dance that N. Tinbergen showed that there was a primary stimulus in all instinctive behaviour, the releaser or stimulus signal. IV, 77.

Stigma: the upper part of the pistil of a flower. III, 66.

Stimulins: hormones secreted by the anterior lobe of the pituitary and controlling the development or the functioning of other endocrine glands (thyroids, adrenal, adrenal cortex and genital glands). VI, 98, 99.

Stimulus: a general term referring to anything in nature that causes excitation in an animal. I, 85; III, 64, 85.

Stimulus signal (or releaser): in animal psychology, the primordial motivation that determines the distinctive social behaviour of a group of animals; eg, in domestic birds, a rough cardboard model in the shape of a bird of prey is a stimulus signal; it automatically causes an escape reaction. IV, 75-78.

Stolons: shoots or runners of plants that behave like the suckers of a strawberry. I, 109; III, 48, 49.

Stoma (ostiole): the opening between two guard-cells. III, 68, 71.

Stomata: the respiratory organ of leaves formed by two cells with an opening (the ostiole) between them that gives passage to air or water. III, 68, 71.

Stones: see Bladder calculi.

Strabismus: a defect of convergence of the two visual axes towards a fixed point: the two eyes do not look in the same direction. VI, 141.

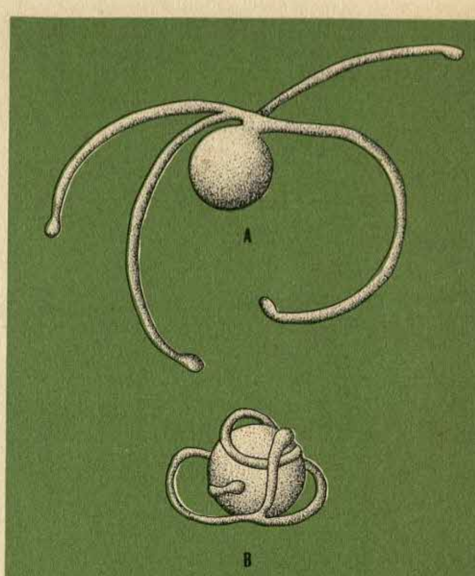
Strain: in biology, a group of organisms of which the pedigree is known; eg, in the laboratory, there are strains of mice and of guinea-pigs. A strain generally presents morphological characters (colour of skin, eyes, average size, etc.) that differentiate it from other strains of the same species. IV, 95, 96, 143.

Streptococcus: a generic name given to bacteria with a rounded form (cocci) grouped in chains. There are a number of varieties, of which the main ones are: *Streptococcus viridans,* the non-haemolytic streptococcus, and the haemolytic streptococcus, of which there are more than forty-nine varieties. The latter are responsible for numerous diseases, septicaemias, acute rheumatic fever, endocarditis, scarlet fever, etc. IV, 85, 135; VI, 18, 19, 22, 23, 32, 33, 34, 51, 55, 56, 94; VII, 34, 82, 83, 85.

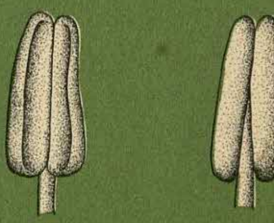
Streptococcus viridans: a variety of streptococcus responsible for local or general infections. Osler's disease or slow malignant endocarditis is the classic and most serious of infections caused by *Streptococcus viridans.* This is localized on a scar of a lesion in the endocardium (acute rheumatic fever); the disease is characterized by successive bouts of fever, anaemia with splenomegaly, peripheral vascular symptoms (cutaneous, articular and renal) and the presence of a cardiac murmur. Osler's disease was fatal before the discovery of penicillin. VII, 120.

Streptomyces: micro-organisms found in the soil that produce antibiotics. From a particular strain of streptomyces, streptomycin is obtained, which is a powerful antibiotic against tuberculosis. III, 72; IV, 70, 74; VII, 83, 86.

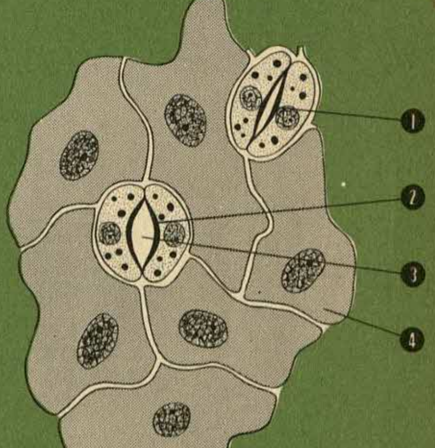
Streptomycin: an antibiotic extracted from the culture of a fungus called *Actinomyces griseus;* it is thermostable and particularly active against Gram-negative organisms, eg, the pneumobacillus of Friedlander, *Pasteurella tularensis,* Pfeiffer's bacillus, and the colibacillus and the tubercle bacillus. It was the first anti-



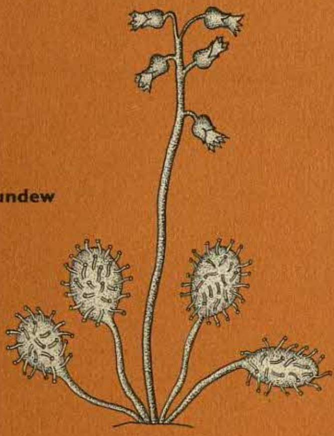
Spore (of *Equisetum Arvense*)
A. In the dry. B. When damp.



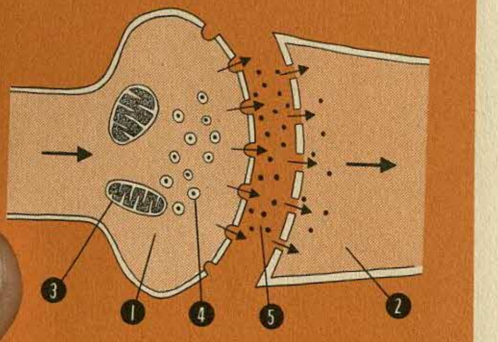
Stamen
A. Anterior view. B. Posterior view.



Stomata (air conducting—dicotyledon)
1. Closed stomata. 2. Open stomata. 3. Ostiole. 4. Epidermal cell.



Sundew



Synapse
1. End of axon. 2. Dendrite. 3. Mitochondrion. 4. Synapticular vesicle. 5. Transmission chemical.

tuberculous antibiotic to be discovered and it transformed the prognosis of this disease in its most frequent localizations (pulmonary tuberculosis, and pleural, bone and renal tuberculosis). It also leads to the cure of tubercular meningitis, which at one time was always fatal. III, 72, 153; IV, 42; VII, 86.

Stress (or adaptation syndrome): stress is a word used by Hans Selye (1936) to designate those non-specific reactions of the organism triggered off by the action of a harmful agent, called the 'stressant'. These agents are of every kind—fatigue, overwork, cold, heat, solar radiation, toxic and infectious agents, operative and traumatic shock, burns, haemorrhage and nervous and emotional shock. The reactions are always identical and non-specific. Stress represents the adaptation of the organism to new conditions with the aim of re-establishing and maintaining it in its original equilibrium. These reactions are characterized by three successive phases: (1) the alarm reaction: the organism is surprised by aggression and goes into a state of sudden shock, with tachycardia, hypotension, diminution of muscle tone, hypothermia, depression of the nervous system and anuria. This state of shock is followed by a state of counter-shock (defence reaction of the organism). (2) The resistance phase, characterized by a number of manifestations that are always non-specific, due to the prolonged exposure of the organism to harmful stimuli to which it has adapted itself during the course of the alarm reaction. If these harmful stimuli disappear, the organism may still regain its equilibrium. (3) The exhaustion stage: if harmful stimulation is prolonged, the organism ceases to be able to adapt itself. The passive phenomena of exhaustion will defeat the manifestations of active defence and will end in death. VII, 56, 57.

Stroke: a sudden paralysis of the nervous system, characterized by stupor and a lowering of temperature, caused especially by haemorrhage (traumatic or operative shock). See Stress and Post-operative shock.

Stroma: in histology, the network of tissue formed generally by connective tissue of which the links sustain the cells. I, 86; III, 25; VII, 95, 96.

Stylops: a small parasite insect of the Strepsiptera order. The *Stylops* causes the loss of sexual character in the host of which it is parasitic. II, 44.

Subculture: tissue culture, a procedure that consists in taking a small part of a culture and transplanting it to a new medium where it will continue to grow. II, 59.

Sub-cortical spot: a characteristic black spot at the vegetative pole of a frog's egg. I, 132.

Substrate: in enzymology, the body on which the enzyme acts. I, 40, 42; V, 51.

Succulence: the quality of plants possessing fleshy leaves or stems. III, 124.

Sulphonamides: a collective name for para-amino-benzine sulphamide and a whole series of similar organic sulphur substances. Sulphonamides exercise a bacteriostatic action *in vitro* and *in vivo* on numerous microbes, such as streptococci, pneumococci, gonococci and meningococci, etc. VI, 33; VII, 82, 85.

Suprarenal: see Adrenal.

Suprarenalectomy: removal of an adrenal gland. VII, 130.

Surgery: a branch of medicine that deals with diseases and disorders by direct intervention; that is, by means of an operation on the organ or tissue in which the illness is located. Surgery is a vast discipline which includes a number of branches that have slightly different aims and use slightly different methods; if an operation involves reaching the affected part of the organism, the particular surgical technique used depends on the problem that is posed. If it is a question of suppressing or resecting an organ or diseased tissue, ablative surgery is used. This branch of surgery, the oldest, is in current use today. It includes, for example, amputation, appendectomy, the removal of stomach ulcers and the gall bladder. Ablative surgery is also used in the case of some localized cancers, such as uterine fibroma and cancer of the breast. A development from ablative surgery is neurosurgery, which consists of disconnecting certain nerve circuits by sectioning the grey or white matter of a brain lobe (lobotomy). With the progress of surgical techniques, another branch of surgery is of increasing importance: this is repair surgery, which aims not only to remove affected organs, but to replace them by healthy ones. It is performed most often on vital organs which cannot be dispensed with and which must be replaced by means of grafts; this is made possible by the remarkable progress of anaesthesia and associated techniques, such as hypothermia and hibernation, as well as by the invention of surgical instruments which are being increasingly perfected, such as clamps for suturing vessels. Arterial grafts or grafts of veins and of bones can now be carried out because there are artery or bone banks and synthetic materials that can be used to replace resected living tissues (eg, artificial arteries made of polyvinyl). A third branch of surgery, often disregarded, is now becoming of greater importance, especially when allied to repair surgery. This is cosmetic surgery, which aims not only to give new faces to individuals who are discontented with their appearance, but also to those injured in accidents. This is done by means of homografts or autografts that replace the cutaneous and subcutaneous tissues that have been lost. A brief mention must also be made of experimental surgery, of which the field is immense, since it is performed on animal embryos and various types of young or adult animals. By eliminating blastomeres or organ rudiments, it aims at solving problems of embryogenesis; or by suppressing an organ essential to life, eg, an endocrine gland, it can throw some light on the physiological function of the organ. I, 139, 150; VII, 16. 17, 103-141.

Symbiont: a being that lives in symbiosis with another. I, 125, 126.

Symbiosis: a physiological association of two or more different species, shown by mutual adaptation of the partners, from which each gets some advantage. The classic example of symbiosis is that of an alga with a fungus to form lichens. But there is also a symbiosis in the association of some bacteria with ruminating mammals: On the one hand, advantage accrues to the former from the optimal constant temperature of the stomach, and on the other, the latter have absolute need for bacteria in order to digest and assimilate cellulose. I, 86, 87; II, 106, 108, 127-132; IV, 65, 66.

Sympathectomy: the removal of a sympathetic nerve along a given length. VII, 131.

Sympathetic system: the complex of fibres and nerve cells that control and regulate sensitivity, movement and secretion of glands and visceral organs. The sympathetic system exercises actions in general, which are antagonistic to the parasympathetic system; the latter slows down cardiac rhythm, which sympathetic nerves accelerate. Both together form the autonomic nervous system. IV, 74; V, 83, 84, 92, 94.

Synapse: a zone of contact and communication between two neurones or between a neurone and a muscle fibre (neuromuscular junction and motor-end plate). The synapse is the seat of processes of transmission of nerve impulses, by means of the intervention of a chemical mediator. It consists of a terminal enlargement of nerve fibre, in which are united mitochondria (generators of chemical energy in the cell) and numerous minute vesicles that contain the chemical mediator.

When the impulses moving along the nerve fibre arrive at the level of the synapse, the chemical mediator is freed from the vesicles and traverses the narrow interneuronic space (between the two cell membranes) and penetrates a dendrite of the second neurone, which causes a change to take place. This change consists of an alteration in the permeability to K^+ and Na^+ ions in the second neurone and by this means causes the transmission of the impulses. The chemical mediator in the neurones of invertebrates and vertebrates appears to be acetyl choline; but it is probable that other substances, such as noradrenaline and p-aminobutyric acid, may play the same role. Synaptic transmission is not automatic. It may be either inhibited or facilitated where the same impulse presents itself several times to the same synapse. This phenomenon of facilitation has been invoked by physiologists in order to explain the fundamental basis of memory and the faculty of learning. IV, 83, 84; V, 65, 66, 69, 73, 76, 78, 79, 80, 81, 119.

Synkarion: the result of the union of two nuclei. I, 103, 106.

Syncope: a momentary arrest of the heartbeat, accompanied by a more or less complete cessation of respiration and a sudden and total loss of consciousness. VII, 52.

Syncytium: a mass of cytoplasm with nuclei derived from the fusion of a number of cells (see Plasmodium). V, 126.

Syndrome: all the symptoms that characterize a disease. VI, passim; VII, 11, 15, 17.

Synecology: the study of the relation of communities of organisms with their environment, in which various climatic, edaphic and biotic factors participate; in other words, it tries to define the habitat of communities and their etiological range, ie, the variation and limits of the factors of the habitat. III, 113, 114.

Synergy: the collaboration of activities of different organs and different muscles; the integration of a number of organs in order to carry out a function. I, 85.

Synthetic environment: a culture medium containing only specified chemical substances, in opposition to environments of which a natural compound (eg, serum) forms a part. I, 69-72; III, 36.

Syntrophism: a relationship established between two cells of which the biochemical capacities and deficiencies differ and which may grow in an environment insufficient for either of them by exchanging metabolites of which each has a need. II, 33; IV, 35.

Syphilis: a contagious disease caused by a spirochaete, *Treponema pallidum*, characterized at the start by a hard chancre, accompanied by adenopathy; it is then manifested by eruptions on the skin and mucosa, and later still, by degenerative lesions of the tissues. It is always transmitted from one person to another, generally during sexual intercourse. IV, 51; VI, 22, 23, 51; VII, 34, 85, 141.

Syrinx: a sound-producing organ in birds, situated between the trachea and the bronchi. I, 84.

Systole: the active phase of the cardiac cycle, corresponding to a contraction of the auricles (auricular systole) or of the ventricles (ventricular systole), during which the blood is expelled from the heart cavities. V, 91, 92, 94; VII, 20.

Systolic murmur: the sound produced in the heart, resembling the noise made by liquid propelled with force into a narrow channel. This murmur is heard during ventricular contraction, and often masks the first sound of the heart-beat. It is sometimes produced by the abnormal passage of blood from one heart cavity to another or into a vessel. V, 92; VII, 121.

T

Tachycardia: acceleration of rhythm of the heart-beats. Tachycardia is slight when pulsation is between 80 and 100 per minute and intense when it exceeds 100. In itself, tachycardia does not constitute a pathological symptom.

TAP: tricyano-amino-propene, a neuroleptic substance that may increase the suggestibility of an individual. VII, 54.

Tardigrade: a class of Arthropods. The tardigrades are very small, being hardly visible to the naked eye. Their bodies are neither segmented nor divided into well-differentiated regions. They are able to live either a slowed-down life or an active one, as in the case of rotifera. Subjected to considerable variations of temperature, or to prolonged desiccation,they can resume a normal existence again as soon as they are moistened by a few drops of water. I, 12, 14; II, 58-62.

Tarsus: the distal part of the limb of an insect. This word is also used for the ankle of mammals. IV, 72.

Taste-bud: a small prominence of the lingual epidermis in which the gustatory cells are located. IV, 74.

Taxis: movement of unicellular organisms (microscopic algae and Protozoa) in relation to their symmetry-structure under the effect of external stimuli. Some micro-organisms displace themselves towards light (phototaxis), others are attracted by heat (thermotaxis), and others by chemical substances (chemotaxis of white blood cells, towards microbial secretions). III, 92.

Taxonomic relationship (taxonomy): morphological, physiological and biochemical relationship that is the basis of the classification of organisms. III, 113; IV, 67.

Tchernoziom: a Russian term signifying 'black earth'. The tchernoziom is the opposite of podzol, inasmuch as the conditions of climate (long dry season) and natural vegetation (mainly herbaceous) do not allow the erosion of the mineral bases, most of which accumulate in the soil which is rich in humus. III, 124.

Telencephalon: the anterior part of the brain that includes the cerebral hemispheres and the corpus striatum. V, 69, 70.

Telolethical egg: an egg in which the yolk is very abundant and forms an inert mass in which development is limited to a disc situated at the animal pole, the germinal disc. Segmentation of the egg is then partial and produces a blastoderm. The typical telolethical egg is a chicken's egg; but those of numerous birds, reptiles, cartilaginous fish (rays and sharks) and some invertebrates (squids and scorpions) also belong to this category. I, 128, 130.

Telome: an elementary organ, elongated and growing in length, owing to the activity of a growing point which, most often, is at the end. A root, a stem, each rib of a leaf, are telomes. III, 47, 48.

Telophase: the last phase of mitosis, characterized by the division of cytoplasm and the formation of two new daughter cells. I, 63.

Temperature: see Body temperature.

Tendrils: small spiral filaments possessed by certain plants that enable them to hold on to supports. Tendrils may either be modified leaves or modified shoots. They are capable of autonomous movements and displacement (circular nutations around an axis, eg, the tendrils of vines, convolvulus and hops). III, 12, 51, 52, 90, 91.

Termite: a neuropterous insect. Termites are mandibulate social insects, characterized by their polymorphism. They avoid light, some are blind, and they live underground or in wood, which they can transform into assimilable food. II, 113-118; mi.

Tertian fever: a form of malaria caused by the protozoon *Plasmodium vivax*. Attacks of fever are separated by one day without fever; this returns on the third day, counting the day of the previous attack. VI, 42, 46.

Testes: male reproduction glands producing spermatozoa. V, 48, 59, 137; VI, 22, 97.

Testosterone: a male sex hormone of vertebrates, produced in the Leydig cells of the testis and responsible for the appearance and the development of male secondary sexual characters. The secretion of testosterone is under the control of one of the gonadoatimulins of the anterior pituitary. I, 32, 150, 151; V, 52, 59, 140; VI, 103.

Tetanus: a disease characterized by painful contractures, beginning generally in the jaw muscles (trismus), then extending to the muscles of the neck, the trunk and the limbs, with convulsive movements that are very painful under the effect of the slightest excitation; this is caused by a toxin from the tetanus bacillus affecting the nerve centres. IV, 83, 84, 130; VI, 22, 67, 70.

Tetracyclines: a group of antibiotics characterized by a chemical structure consisting of four condensed 6-carbon rings that are closely related to naphthacane hydrocarbon. Tetracyclines differ from one another by the nature of the substitutions carried out on the rings. The principal tetracyclines in clinical use are chloretetra–cycline, oxytetracycline, demethyl chlorotetracycline 6, and tetracycline itself. VII, 87.

Thalamus: the nucleus of grey matter situated inside the brain on each side of the third ventricle. VII, 58, 138.

Thalassotherapy: the therapeutic use of sea-bathing or holidays by the sea. VII, 146.

Thallophyte: this includes algae, fungi and lichens; plants in which the cells are not arranged in tissues and of which the body is constituted by the thallus. III, 46-49, 50.

Thallus: the vegetative apparatus of algae and fungi formed by non-differentiated tissues. The thallus of algae contains chlorophyll and sometimes other pigments; that of fungi contains no chlorophyll. III, 46, 48

Thermolabile: a substance that is destroyed or inactivated by heat. I, 134, 137. V, 35, 36.

Thermoperiodicity: a phenomenon in which plants react to thermal changes of daily or annual rhythm. This regular alternation of temperature is absolutely essential to normal growth and it has been possible in a certain number of cases (and especially in cultivated plants) to determine the optimal thermoperiodic cycle to obtain the best possible yield. Thermoperiodicity is often linked with photoperiodicity. In a daily cycle, the plant undergoes two changes in twenty-four hours: between day temperatures that are relatively high and night temperatures that are relatively low. These alterations are essential for the optimal development of the tomato, for example, and the camellia. But daily thermoperiodicity is peculiar to certain plants, especially those of the temperate zone. Annual or seasonal cycles are a much more general phenomenon. Thermoperiodicity is often closely linked to phenomena of dormancy. In some plants (with or without flowers) a period of a few weeks or a few months at low temperature is absolutely essential for normal development. The most remarkable case of thermoperiodicity is that of plants with bulbs (tulips, hyacinths and iris): bulbs planted in November, although already carrying complete floral buds, cannot flower except in the spring that follows, after a period of thirteen weeks in the cold (8°C to 9°C). The rational study of thermoperiodicity is very advanced in the case of cultivated plants because of its economic importance, and it has been greatly facilitated by the invention of phytotrons. III, 19, 99-101.

Thermoregulation: the automatic regulation of the internal temperature in homeothermic organisms (higher vertebrates). Thermoregulation depends on a central regulator situated at the base of the brain, which, under a change of internal temperature of the order of 0·1°C, sets in train a number of physiological reactions, (sweating, constriction of peripheral vessels, etc) aiming to restore normal temperature. III, 101; V, 151, 154.

Thiamine: see Vitamin B$_2$.

Thiol: a molecule with an atom of sulphur linked to a hydrogen atom on one side and a carbon atom on the other. VII, 91.

Thoracography: the study of the diffusion capacity of the alveolar membrane of the lungs, observed by means of radio-active oxygen administered by inhalation. Recording is made by geiger counters and scintillation counters. This operation must take place very near the cyclotron, because the half-life of radioactive oxygen is very short. VII, 22.

Thoracotomy: surgical opening of the thorax, often with removal of a rib, to permit an operation on a lung or on the heart. VII, 53.

Thrombin: an enzyme in the blood plasma which, in catalyzing the transformation of fibrinogen into soluble fibrin, causes the formation of a clot and stops the blood flow. V, 35, 36, 37.

Thrombocytes (or blood platelets): discs of cytoplasm, two or three microns in diameter, that plan an essential part in the coagulation of blood, agglutinating in vascular lesions and leading to the formation of a clot. Thrombocytes come from special cells in the bone marrow which, after having lost their nucleus, are fragmented into small pieces. There are between 200,000 and 300,000 per mm^3 of blood. IV, 121; V, 30, 31, 34, 36, 37; VII, 53.

Thromboplastin: a plasmic enzyme essential for the coagulation of blood. In the presence of calcium it transforms prothrombin into thrombin. V, 35, 36.

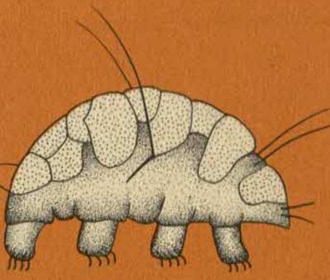
Thrombosis: the obliteration of the cavity of a blood vessel by a clot (thrombus). VI, 43, 84, 111.

Thrush: a disease caused by the development of a parasitic fungus (*Candida albicans*) in the mucosa of the mouth, characterized by patches of a whitish creamy consistency. VII, 99.

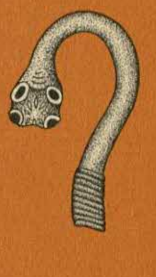
Thymus: a gland situated in front of the trachea between the lungs. It is present in children up to the age of twelve or thirteen, then atrophies and disappears. Its role is little known, though it is without doubt the basis of phenomena of natural immunity. I, 51; mi.

Thyreostimulin: a hormone secreted by the anterior lobe of the pituitary which stimulates the function of the thyroid gland. VII, 15.

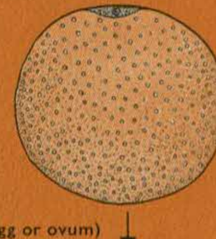
Thyroid: a gland of internal secretion situated in the neck near the trachea, above and on each side of the larynx. It secretes a very important hormone, thyroxin, which regulates growth and cell metabolism. II, 111; V, 48, 52, 72, 137; VI, 14, 57, 88, 97-99, 100, 102, 106, 119, 120, 147, 149, 150; VII, 14, 15, 23, 94; mi.



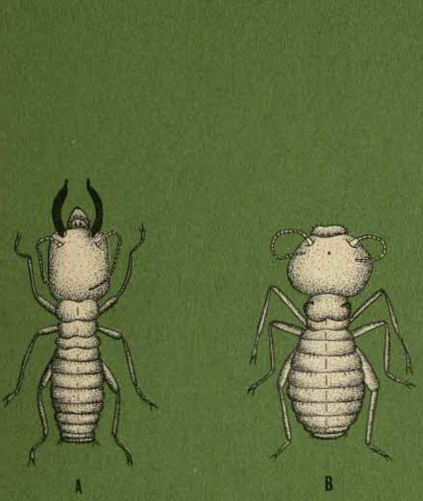
Tardigrada



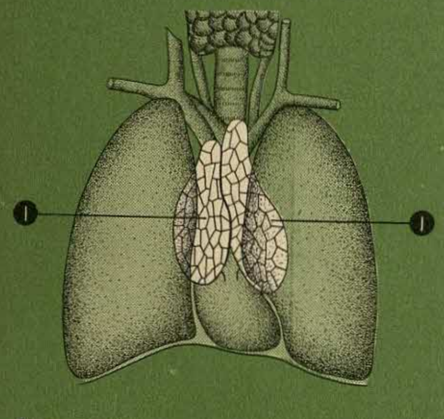
Taenia



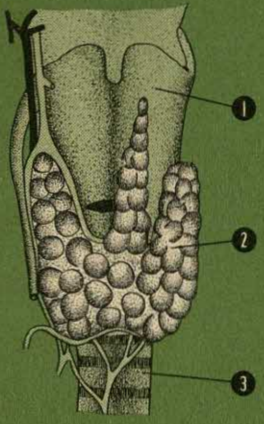
Telolethical (egg or ovum)



Termites
A. Soldier. B. Worker.



Thymus
1. Right and left lobes of the thymus.



Thyroid gland
1. Thyroid cartilage. 2. Thyroid gland. 3. Larynx.

Thyroxine: a hormone produced by the thyroid gland that acts both on growth and metamorphosis and on the intensity of metabolism. II, 35; V, 52; VI, 14, 99; VII, 15.

Tigella: part of the embryo plant in seeds which will form the stem of the plant. III, 62.

Tissue: the natural grouping of cells that have the same structure and the same physiological function. Every multicellular living organism is formed of tissues which, depending on their embryological origin, have different functions. In man there are covering tissues, supporting tissues, muscular tissues, and nervous tissues. Covering tissues, such as the skin, the mucosa, the wall of the digestive tract, and glandular tissues, can renew themselves easily and rapidly. Supporting tissues include, in addition to connective tissue and bone and cartilage, the blood, the elements of which come from the bone marrow. Muscular tissue is formed of contractile elements; muscle fibres, and nerve fibres are constituted by nerve cells prolonged into axons; such tissue is very highly differentiated, the elements renew themselves very little or not at all. These categories of tissues exist in all animals, both vertebrates and invertebrates. In all living organisms, the tissues themselves are grouped to form organs. I, 60, 61, 64, 65, 66, 67, 79, 96; V, 135, 136.

Tissue affinity: the capacity of different tissues to form a mixed tissue when placed in contact. This affinity of tissues is often selective; that is to say, it only shows itself in the case of well-differentiated tissues. I, 75, 76, 77.

Tomography: a process of radiological exploration for obtaining a radiograph of a very fine layer of an organ at a desired depth. The principle of the method depends on the simultaneous displacement of the emitting tube and film around an axis which passes through the section. All images at a distance from the axis of rotation are blurred, but the images situated around the axis are accurately reproduced on the plate. This technique enables analysis of tissues to be made section by section and suppresses the summation of images. Tomography makes it possible to isolate the lesion from the shadows in front of or behind it and enables anomalies to be shown that are invisible in direct radiography. It is used in the radiological exploration of the lung, bone, spinal column and larynx and permits a complete topographical analysis in front view and in profile. An improvement on the process is serial tomography; a series of photographs are taken simultaneously, and each photograph shows images of sections corresponding to their distance apart. The time of exposure to x-rays is thus diminished. VII, 21.

Tonus: in general, the state of permanent activity and variable intensity of an apparatus, a system or an organ (sympathetic, muscular and vasomotor tonus). V, 92, 94, 131, 132.

Totipotent: a cell capable of carrying out under certain conditions any of the cytological differentiations characteristic of its species or capable, by cell division, of giving rise to these differentiations. In the adult, it describes a cell that resembles an embryonic cell in its properties and is capable of regenerating any part of an organism that is destroyed or wounded. Such cells exist in different groups of invertebrates: planaria, starfish, hydra, etc. They are also called regeneration cells. I, 95, 96, 98, 134, 135.

Toxic shock: modifications undergone by an organism following injection of toxins. Toxic shock shows itself by disturbances of circulation, hyperthermia, hyperglycaemia and diminution in the number of white cells It represents an anaphylactic type of reaction of the organism to endotoxins. IV, 29.

Toxin: a poison of plant, animal, or microbial origin that generally acts as an antigen. According to their origin and method of action, toxins are called, more specifically, endotoxins (q.v.), exotoxins (q.v.), or antitoxins (q.v.), etc. III, 69.

Toxoid (anatoxin): microbial toxin which has lost its toxic properties but not its immunizing properties. IV, 27, 132, 134.

Toxoid vaccination: vaccination by means of toxoids obtained by adding formol to a toxin and maintaining it at a certain temperature for several weeks. The toxin then loses its toxic properties and preserves its immunizing ones. (eg, diphtheria toxoid and tetanus toxoid). VII, 81, 82.

Toxoplasmosis: a disorder caused by *Toxoplasma*, a parasitic protozoon of numerous domestic animals. The method of contamination is unknown. The acute congenital form, from which death usually occurs, causes progressive hydrocephalus and retinitis; radiological examination often shows numerous intracerebral calcifications. The acquired forms in children and adults are much more frequent. Usually these are clinically not apparent, but may nevertheless affect a number of organs (lungs, heart and lymph nodes) and the clinical picture is close to that of infectious mononucleosis. VI, 143.

Trabeculae: fine filaments which, by means of an astomosis, form a reticulated tissue.

Trace elements: chemical elements (eg zinc, copper, manganese, etc.) required in very small quantities in the chemical composition of living matter. III, 31-34, 139.

Tracheid' an elongated cell, forming part of the wood of a plant; sap circulates from one tracheid to another by means of special openings called 'bordered pits'. III, 149.

Tracheotomy: a surgical incision of the trachea which allows the patient to breathe in the event of obstruction of the respiratory pathways; it also permits assisted respiration in the case of insufficient breathing or paralysis (poliomyelitis). VII, 51, 56.

Tranquillizers: substances designed to ease the anxiety of nervous cases. Their discovery has revolutionized the field of mental disease, neuroses, and psychoses. They are roughly grouped into two large categories: the phenothiazine derivatives (largactil, spearine, etc.) and those of the Rauwolfia alkaloids. Their main effect is to relieve anxiety, but their effects on the nervous system are varied: they are used with success against nausea, vomiting, itching, hyperthermia, asthma, allergic reactions, hypertension, and stresses of all kinds. VII, 54.

Transducer: a receiver of energy which passes it on to another system, generally in a different form. Such are the sensory organs that transform mechanical and light energy, etc. into electrical energy in the form of nerve impulses. II, 65, 69.

Transduction: in bacteria, the transfer of an hereditary character from one bacterium line to another by means of a bacteriophage. The bacteriophage, mainly constituted of DNA, sometimes exists in latent form (prophage) in a bacterium: it then incorporates itself more or less completely into its host and when, for a reason yet unknown, it becomes virulent, it carries one or more genes of this host which it transfers to a new bacterial host. This form of gene exchange is considered to be a particular case of transformation, but it is possible that transduction has a much wider biological significance and constitutes, for example, the beginning of sexual reproduction, in which the bacteriophage would be the sexual determinant, the Y chromosome of higher organized beings; this is a hypothesis put forward by F. Jacob. IV, 33, 34, 108.

Transference: in psycho-analysis, the term that describes the effect on the personality of the therapist of all the expectations of the patient. The transfer of the patient's emotions on to his doctor corresponds in the latter to the counter-transfer, the totality of affective conscious and unconscious reactions that the therapist feels toward the patient and which he must clarify to himself and master in order not to harm the confidence and sincerity of his patient. VII, 43, 46.

Transformation: the acquisition by a bacterium of new hereditary characters after the penetration of a fragment of chromosome coming from a killed bacterium of a different strain. The chromosome fragment, generally very small, is integrated into the genome of the bacterium, not by addition, but by substitution: there is thus a direct gene exchange without sexual reproduction. The phenomenon of transformation, first elucidated in 1944, is one of the most important in modern genetics. I, 50, 51; IV, 32-34, 47, 48, 50.

Transposition: a faculty possessed by some animals (crows and jackdaws) of recognizing a number (up to 5) by means of a visual stimulus, which enables them to transpose this knowledge without any apprenticeship in to an auditory stimulus and vice versa. II, 96.

Traumatology: a branch of pathology devoted to the study of wounds and casuality surgery in the case of road accidents and industrial injuries. VII, 111-119.

Trepanation: an operation that consists in making a hole in a bone, either with a trepan or a gouge and mallet. This term is used especially when dealing with bones of the skull which have been perforated. VII, 135, 136.

Treponema: a spirochaete bacterium in the form of a spiral filament which is mobile and moves by jerks. It is the cause of syphilis. IV, 51, 126.

Trichromatism: a property of the human retina as a result of which any colour can be produced from combinations of the three primary colours. The retina has in it three kinds of pigments that are photosensitive and are characteristic of three kinds of cones (Thomas Young's theory). V, 107, 110, 111.

Trichomonas vaginalis: a flagellated protozoon, a parasite of the vaginal mucosa. IV, 120.

Trichophyte: a parasite fungus that may be localized in the skin of the head, where it causes a form of tinea; or it may be in the beard, where it causes sycosis, or in other hairy regions of the body where it causes herpes, and also on the nails, which are then affected by trichophytic onychomycosis. VII, 88.

Tricuspid atresia: see Atresia, tricuspid.

Trioses: sugars with three carbon atoms. Trioses play an important part in the Krebs' cycle in a form that is linked to phosphates (triose phosphate). III, 28, 29.

Triploblastic: multicellular animals in which all tissues are formed from the three embryonic layers, the ectoderm, the mesoderm, and the endoderm. See Diploplastic. I, 87, 88; II, 17.

Trochophore: a swimming larva of the annelids: it is found among other kinds of worms and in certain molluscs. It is microscopic, formed like a top, unsegmented, and possesses bilateral symmetry. I, 19, 87, 89, 90; mi.

Tropism: the displacement of an organism in a given direction under the effect of an external excitation of physical or chemical origin. Tropisms also exist in plants (eg, the movement of flowers towards light) and in animals. III, 12, 83, 92-94.

Trypanosomes: flagellate protozoa, generally of a slender shape, with a single flagellum directed forwards. They are parasites, often with a complex life cycle. Some are pathogenic to man; the best known is *Trypanosoma gambiense*, which causes sleeping sickness, transmitted by the tsetse fly. I, 125, 126; IV, 126; VI, 41; mi.

Trypsin: a ferment secreted by the

pancreas; it acts on proteins and in an alkaline medium and dissolves and hydrolizes them, changing them into peptones and amino acids. IV, 95.

Tuberculin: a name given to different substances extracted from cultures of the tubercle bacillus. It is a sterile liquid containing toxins produced by the tubercle bacillus and is used in the skin-reaction test. VII, 40, 80.

Tuberculosis: an infectious disease, common in man and animals, caused by Koch's bacillus. Anatomically, it is characterized by the dissemination of bacilli in part or all of an organism, and by the formation around each bacterial focus, of an inflammation that takes on the general aspect of the tubercle. Clinically, its aspect is different according to whether it has rapidly invaded the whole organism (granulia) or remained more or less localized in the tissues where it has undergone its different stages. This disorder is disappearing, owing to early detection and the use of anti-tuberculous antibiotics and B.C.G. vaccination. IV, 138, 139; VI, 19, 22-28, 51, 62, 64, 70, 71, 77, 90, 94, 95, 112, 116, 122, 126, 133, 140, 146; VII, 17, 29, 34, 35, 38, 43, 66, 80, 86, 153.

Tubular excretion: in renal physiology, activity of the cells of the U-tube of each nephron, by means of which the final composition of urine is determined: this phenomenon results in a specific active secretion of certain substances in the blood which are then completely eliminated from inside the internal environment; eg, it is by means of tubular excretion, and not by glomerular filtration, that substances that have been ingested during treatment are eliminated (penicillin) or during functional investigation (iodized substance). V, 23, 24, 26, 136.

Tubular reabsorption: a fundamental function of the uriniferous tubule of the nephron, which consists in the retention by the cells of part of the tube, of certain substances that have been excreted by other parts of the nephron. V, 22-24, 26, 136; VII, 26.

Tubule: see Renal tubule.

Tumour: a general term for pathological products resulting from a newly formed tissue that is proliferating in an anarchic fashion. There are benign tumours in which the proliferation remains localized and which do not reappear after removal. Malignant tumours (ie, cancer) extend rapidly and have a tendency to spread or recur after removal, and to metastase some distance from the original tumour. III, 70; IV, 98, 100, 102, 103; VI, 71, 102, 120, 121, 130; VII, 11, 22, 23, 29, 30.

Tundra: a plant-association of cold-climate regions. It is characterized by ligneous plants, such as birch trees and by grasses, mosses and lichens. III, 124.

Tunica: the tissue that constitutes the wall of blood vessels. The vessels are composed of three tunicae: (1) an internal one constituted by an endothelium which, unlike most surfaces, does not promote the coagulation of blood; (2) a middle one composed of muscle fibre and elastic fibre (the muscle fibres enable the arteries to cushion the pulse pressure caused by the systolic contraction of the heart: the elastic fibres enable the arteries to increase or to reduce their calibre); (3) an external one, formed by connective tissue, on which terminate the nerve fibres (vasodilators and vasoconstrictors) that act on the muscle fibres of the middle tunica. VII, 96.

Turbellaria: a class that forms part of the Platyhelminthes phylum. These are flat worms with a cilated epidermis. Essentially, they include the planarias, which live in fresh water. They also live in damp soil and sometimes in sea-water. II, 14, 17.

Twins: young born at one birth from the same mother in man and other vertebrates. It is important to distinguish: (1) dizygotic twins (or ordinary twins) which come from two separate eggs that are developed at the same time; (2) monozygotic (uniovular) twins, identical twins resulting from a single egg that has split into two embryos at the beginning of development. Identical twins have the same genotype: they constitute 'the same individual cast in two specimens'. The study of these is of the greatest interest in biology, genetics and psychology. I, 115; V, 72, 138.

Tympanic membrane: a thin membrane, roughly circular in shape, forming the external wall of the middle ear and separating it from the external auditory meatus. On the internal surface of the tympanic membrane, an ossicle, the hammer (malleus) is attached. The membrane vibrates when sound waves impinge on it. V, 112, 114, 116, 117.

Typhoid fever: a contagious disease, characterized by a rise in temperature, a state of prostration, eruption of reddish lenticular spots and nervous and intestinal disturbances caused by a lesion of the intestinal mucosa. Typhoid fever is caused by Eberth's bacillus. IV, 131; VI, 19, 22, 23, 30.

Typhus, endemic (or murine typhus): a disease of rats, transmitted from the rat to man by a flea. Its characteristics are those of exanthematous typhus, but attenuated. This disease is caused by a rickettsia, *Rickettsia mooseri*. VI, 19.

Tyrocidine: see Tyrothricine.

Tyrothricine: an antibiotic substance (a mixture of 80% tyrocidine and 20% gramicidine) extracted from *Bacillus brevis*, which is active against aerobic Gram-positive organisms and some anaerobic ones, generally toxic; it is a powerful bacteriostatic on the skin and the mucosa (eg, against sore throat) in local application. VII, 88.

U

Ultracentrifugation: centrifugation at great speeds. The sedimentation rate of a virus is dependent on its size. One can therefore calculate the dimensions of a virus by ultracentrifugation. IV, 106.

Ultrafiltration: filtration through collodion or cellophane membranes. In searching for membranes that allow viruses to pass and noting which membranes do not allow them to do so, it is possible to deduce the dimensions of the virus being studied. IV, 106; V, 24.

Undulating fever: the intermittent febrile cycle of brucellosis. VI, 22.

Unicellular organisms: primitive entities composed of a single cell and showing either animal tendencies, as in the case of protozoa, or plant tendencies, as in the case of protophytes. I, 112.

Unipotent: cells capable of only one type of differentiation. In the embryo, when neurulation has been completed, the majority of cells have lost their totipotent capacity, that is to say, the ability to differentiate into any of the cell categories of the future adult organism except their own. I, 134, 136.

Urea: a chemical substance representing the last phase in the degradation of proteins. It is formed in the liver and is eliminated in the kidneys. The increase in its level in the blood (uraemia) is a characteristic of certain diseases (nephritis, uraemia, and poisoning). V, 24; VII, 14, 26, 28, 51, 62, 85.

Uredinales: basidiomycete fungi, parasitic on higher plants, that form superficial orange spots on plants, whence the name rust which is given to them in horticulture. III, 59, 68.

Uredospore: a red spore of rust (parasite) that germinates in summer (as opposed to teleutospores, black spores that survive the winter and germinate in spring). III, 68, 71.

Ureters: tubes that extend from the kidneys to the bladder. They penetrate the posterior abdominal wall, behind the peritoneum, turn into the abdominal cavity and reach the lower posterior face of the bladder. Their total length in man is approximately 25 cm. VII, 11, 105.

Urinary casts: microscopic cylinders of protein substance which form in the uriniferous tubules. They are found as deposits in urine. Their composition is variable. They are: (1) amorphous, colloidal, waxy, or mucous cylinders; (2) cylinders constituted by elements of the blood (red cells and leucocytes); their analysis is important in the diagnosis of certain diseases and these are the only ones that are of any pathological importance. VII, 34.

Urinary cylinders: see Urinary casts.

Urography: radiography of the kidneys, made after intravenous injection of a substance opaque to x-rays and which is eliminated rapidly in the urine. Functional insufficiency shows itself by a delay in the elimination of the substance. Anatomical lesions of the kidneys and their excretory ducts are shown on the photographs. The opaque substances that are used are iodated bodies. VII, 25, 26.

Urticinae: an order of higher plants including the family of Urticaceae and the genus *Urtica*, or common stinging-nettle. III, 55.

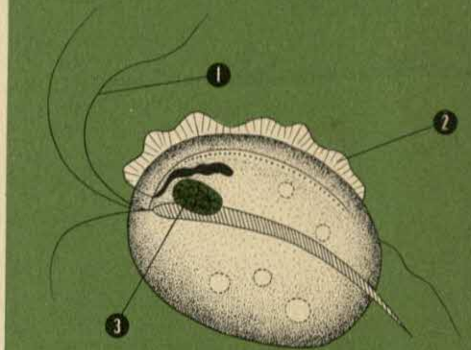
Urticaria: a cutaneous eruption which, most frequently, is a reaction of hypersensitivity to a chemical substance introduced into the organism either by simple contact with the skin or through food. VI, 50; VII, 68.

Uterus: a hollow muscular organ situated, in female higher vertebrates, in the pelvic cavity between the bladder and the rectum, above the vagina and below the Fallopian tubes. It has a body and a neck, separated by the isthmus of the uterus. The uterus itself is composed of three tunicae: an external serous one, the peritoneum; a middle one, muscular, thick and composed of smooth muscle fibre arranged in three layers (this plays an important part in the expulsion of the foetus at the moment of delivery); and an internal mucosa or endometrium that lines the cavity and furnishes a nesting place for the fertilized ovum. The mucosa exfoliates at each menstruation, but regenerates and renews itself periodically. I, 144, 145, 150; V, 58; VI, 103; VII, 34, 94, 110; mi.

V

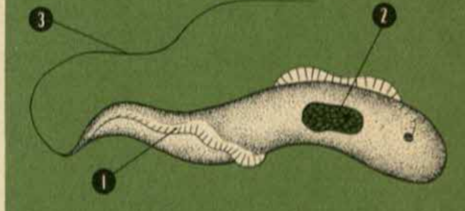
Vaccination: deliberate introduction into the organism of a pathogenic germ with the aim of producing immunity. Vaccines are based on killed pathogenic agents (vaccine against typhoid and yellow fever) or on organisms the virulence of which is strongly attenuated (smallpox vaccine and some antipolio vaccines), or on toxins secreted by the pathogenic organisms themselves (diphtheria vaccines and tetanus vaccines). IV, 130, 132-135; VI, 28, 31, 34, 38, 39, 116; VII, 68.

Vaccinia: a disease related to smallpox which occurs spontaneously in the horse (horsepox) or in the cow (cowpox). Studies of this disease by Edward Jenner (1798), were the beginning of the technique of vaccination. VI, 19, 23.

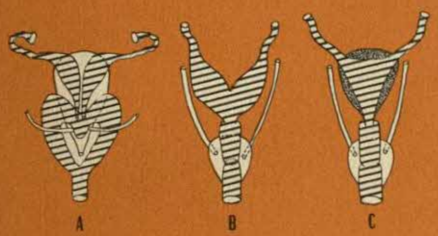


Trichomonas
1. Anterior flagella. 2. Undulating membrane. 3. Nucleus.

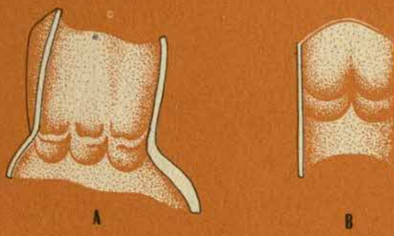
Trochophore (or Trochosphore larva)



Trypanosoma gambiense
1. Undulating membrane. 2. Nucleus. 3. Flagella.



Uterus
A. Marsupial. B. Rodent. C. Primate.



Valve
A. Sigmoid valve (aortic). B. Venous valve.

Vacuoles: lipidic or aqueous inclusions of the living cell that have a number of substances in them, either dissolved or precipitated. A vacuole is called 'contractile' when it swells and empties periodically, thereby maintaining the constancy of the internal environment, in particular that of osmotic pressure, which is proportional to the concentration of dissolved substances in the protoplasm and inversely proportional to their molecular weight. I, 85; III, 16, 17, 76; V, 46.

Vagus nerve: the tenth cranial nerve. It is the large nerve of the parasympathetic autonomic system that innervates numerous organs, heart, lungs and digestive tract and regulates their function. Its action is antagonistic to that of the sympathetic nervous system. V, 67, 92, 134; VII, 60, 105, 130.

Valvular insufficiency: insufficient closure of a cardiac orifice because of defective valves (auriculo-ventricular valves and aortic sigmoid valves), causing a reflux of part of the blood in the heart cavity. VII, 118.

Valvule: a thin elastic sheet fixed on the internal wall of a blood vessel or of the heart which prevents blood from flowing back. In the heart, the valves separate the auricles from the ventricles; in the veins, where pressure is very weak, certain valves shaped like cups maintain the regular circulation of the blood in the normal direction. VII, 118; s.

Varicella: see Chicken-pox.

Vascular collapse: a sudden lowering of blood pressure, associated with a barely perceptible accelerated pulse, a leaden complexion, cooling of the limbs and a condition of syncope, caused by an extensive haemorrhage, or a sudden generalized vasodilatation. Collapse is combated in a case of haemorrhage by perfusion or plasma perfusion, in other cases by intravenous injection of noradrenaline. VII, 31, 53, 68.

Vascular plants: vascular Cryptograms and Angiosperms, possessing vessels through which the sap flows. III, 11, 50.

Vasopressin: see Pitressin.

Vector: in medical biology, an intermediary agent that transports viruses, bacteria, or parasites responsible for infectious diseases (these are mainly arthropods and blood-parasites, such as fleas, mosquitoes and ticks). VII, 74-78.

Vegetative reproduction: a method of asexual reproduction found in plants and animals and produced, for example, by stolons, buds, or suckers. See also Budding, vegetative. III, 19, 39, 44.

Veno-arterial shunt: a malformation characterized by an abnormal communication between two cavities of the heart or between two vessels. This causes the passage of oxygenated arterial blood from the systematic circulation into the blood of the pulmonary circulation. This leads to an arterio-venous shunt, which is, in brief, a left-right shunt. VII, 119, 120, 122.

Venom: a toxic liquid secreted by special glands in numerous animals, eg, spiders, scorpions and snakes, that is inoculated into the organism by a bite. Venoms may be neurotoxic, with a curarizing action causing respiratory paralysis (venom of the cobra or the rattlesnake); shock-producing, through the liberation of histamine (venom of the viperine snakes); haemorrhagic through antithrombin action (naja); or haemolytic by fibrinolytic action (viperines). IV, 152, 153.

Ventriculography: a method of observation of the brain, consisting in replacing the liquid contained in the ventricles of the brain by air: deformations of the ventricular system make it possible to localize tumours with precision. VII, 137.

Vernalization (or yarovization): in plant biology, the favourable effect caused by cold on the flowering of plants; also applied to a method which, by the appropriate treatment of seed, makes it possible to delay the sowing of winter cereals until springtime, and nevertheless to obtain flowers and the formation of ears in the same year, as if they were spring cereals. The seeds are put to germinate, and then their germination is stopped at a very early stage by the action of cold. Cold is thus essential to vernalization, but, contrary to current opinion, it does not stimulate flowering; it delays it until the following spring. III, 100, 101, 104-107.

Vesicant: an irritating substance producing blisters on the skin and epithelial lesions in passages, such as the respiratory mucosae (vesicant gas) or the digestive tract. VII, 90, 91.

Vibrio: see Cholera vibrio.

Viral defence: the defence of the organism against viruses. This is effected principally by two mechanisms: (1) the production of specific antibodies in serum; (2) the production of interferon in the cells. IV, 141.

Virulence, bacterial: a property possessed by a pathogenic germ of multiplying in an organism, and consequently escaping from the natural means of the organism's defence (phagocytes, antibodies, etc.). IV, 85-88.

Virus: a sub-microscopic entity at the lower limit of size of the living world, varying in size between 35 and 250 millimicrons. Viruses at one time called ultrafiltrable viruses, because they can go through the pores of porcelain vessels) are only visible in the electron microscope. Essentially, they are constituted of nucleic acid (DNA or RNA) and of special proteins, the histones. Practically without enzymes, viruses cannot perform their own metabolism. These special characters condition their mode of existance; viruses are always intracellular parasites and their vital functions are reduced to auto-replication of their nucleic acid. There are viruses that parasitize animals, plants and bacteria (bacteriophages). Viruses are responsible for some of the most deadly epidemics suffered by man and animals (smallpox, yellow fever, influenza, and myxomatosis) and a large number of other diseases are attributed to them (measles, chicken-pox and poliomyelitis). There is as yet no general curative treatment for virus diseases. In most of the more serious viral infections vaccines are used which are prepared either with living attenuated viruses or killed viruses. Since 1957, the discovery of interferon has opened a new path in treatment of virus diseases. I, 15, 16, 54; II, 20, 158; IV, 20, 21, 22, 89 et seq. VI, 14, 22, 23, 29-31, 35, 37, 54, 130, 135; VII, 14; mi.; H.

Visual pigments: photosensitive biochemical substances contained in certain cells of the retina (eg, rhodopsin). V, 106.

Vital capacity: the volume of air expired when a forced inspiration is followed by a forced expiration (usually about 4 litres). V, 15, 136, 137; VII, 24.

Vital staining: colouring that puts certain cell constituents of a living organism into prominence. I, 59, 64, 65, 74, 108, 109, 133, 134; IV, 52.

Vitamin: a chemical substance contained in food in the form of traces, a deficiency of which leads to the appearance of very serious diseases (scurvy, pellagra, beri-beri and rickets). The vitamins now known are more than twenty in number and may be conventionally divided into two groups: those that dissolve in fatty substances (vitamins A, D, E, F, and K); and those that are soluble in water (vitamins of the groups, B, B_1, B_2, PP, B_6, B_{12}, vitamin C, biotine, folic acid, etc.). Provision of vitamins in food is absolutely essential for all organisms that cannot synthesize them for themselves (as is the case in practically all heterotrophic organisms), since the majority of these substances play a part as enzymes in metabolic reactions of the cell, or in synthetic reactions (vitamin B_{12}, folic acid in the synthesis of certain constituents of nucleic acids), or in degradation reaction (vitamin B in the Krebs' cycle; vitamin E and biotine in the final phases of cell respiration). The chemical formula of all vitamins is well known and all of them may be obtained by synthesis (either by chemical means, or with the help of bacteria, as in the case of vitamin B_{12}). Vitamin therapy, a branch of medicine by means of which it is hoped to cure a certain number of metabolic disturbances, is today being widely developed. III, 30, 34, 153; V, 24, 50-53; VI, 14, 79, 109; VII, 117.

Vitamin A (or retinol): a fat-soluble vitamin, abundant in the liver of some fish (cod and halibut), as well as in certain vegetables, in the form of pro-vitamin A (carotene). A deficiency of vitamin A leads to serious disturbances of vision (xerophthalmia) which may lead to blindness. Vitamin A forms part of the composition of rhodopsin, the visual pigment of the rod cells of the retina. It also plays an important part in the cicatrization of wounds and burns. V, 52; VI, 15.

Vitamin B_1 (or thiamine water): a soluble vitamin, a deficiency of which causes beri-beri. Thiamine is abundant in the coverings of seeds (rice, wheat and nuts). It plays an essential role in cell respiration, and sets off the metabolic Krebs' cycle, during which glucose is broken down into carbon dioxide and water. III, 42, 153; V, 52, 53; VI, 109.

Vitamin B_5 (or pantothenic acid): a vitamin essential to the breaking down of glucose in the cells: it takes part in the initial stage of the Krebs' cycle in the form of co-enzyme A. Deficiency in pantothenic acid, which is rarely observed, shows itself especially in the form of cutaneous lesions. An experimental deficiency in female pregnant rats produces characteristic malformations of the foetus (absence of eyes, and haemorrhagic oedemas in the limbs). V, 52.

Vitamin B_6 (or pyridoxin): very abundant in yeast, cereals and royal jelly of bees, vitamin B_6 is essential both as an enzyme and in many metabolic reactions; in particular, the synthesis of glutamic acid, which is required for the normal functioning of the nerve cells. Deficiencies in vitamin B_6 are shown by nervous disturbances (epileptic contractions and convulsions). III, 29, 30; V, 53.

Vitamin B_{12} (or cyanocobalamine): a hydrosoluble vitamin that plays an essential part in the formation of red cells. This vitamin, which is exclusively synthesized by bacteria, cannot be absorbed by the intestinal cells of man except in the presence of a substance known as the intrinsic factor, secreted by certain cells of the stomach. The absence of this factor, which leads to a deficiency in vitamin B_{12}, causes pernicious anaemia (Biermer's anaemia). III, 153; IV, 66; V, 53; VI, 79.

Vitamin C (or ascorbic acid): a water-soluble antiscorbutic vitamin that exists in fruit and vegetables (oranges, lemons, parsley and cabbages). Vitamin C has a number of functions; it appears to play a part of great importance in the function of the adrenal cortex, especially in conditions of stress. It also takes part in the synthesis of collagen and it is essential for the metabolism of glucose in cell respiration. Vitamin C has several therapeutic uses (in cases of infectious diseases, fatigue). V, 52; VI, 109.

Vitamin D: an anti-rachitic vitamin derived from sterols; it is formed in certain cells of the skin under the effect of ultra-violet sun rays. The food sources from which vitamin D are derived are not very numerous and are exclusively animal (cod liver and halibut liver). Vitamin D acts on bone formation by exercising a regulatory function in the metabolism of calcium phosphate and maintains a constant level of calcium and phosphorous in the plasma; it also helps the intestinal absorption of calcium as well as the reabsorption of phosphorous in the uriniferous tubules. It is sometimes prescribed for infantile tubercular lupus because of its pharmacodynamic properties. V, 52; VII, 148.

Vitamin E (or fertility vitamin): a vitamin consisting of seven substances of related chemical nature, the tocopherols, of which a deficiency in certain mammals leads, in males, to the arrest of spermatogenesis, and in females to the sudden cessation of gestation. The vitamin apparently acts on the anterior pituitary and increases the level of prolans A and B. Apart from its anti-sterility function, this vitamin is essential for the differentiation of collagen and the metabolism of the muscle cells, perhaps as a transporter of hydrogen (tocopherol is destroyed during the course of muscle contraction). III, 153; V, 52.

Vitamin H (or biotine): a vitamin of the B group, required in very small amounts, a deficiency of which can only be observed experimentally. It is essential for metabolism as a co-enzyme in the final phases of cell respiration (hydrogen transport). It appears also that biotine is a growth factor, since embryonic tissues and cancer tissues are very rich in it. V, 52.

Vitamin K (or coagulation vitamin): a vitamin essential for the synthesis of prothrombin and of which a deficiency results in spontaneous haemorrhages. It exists in the liver of ruminants (synthesized by certain bacteria). It is probably also to be found, although in small amounts, in chloroplasts of all green plants; it appears to play an essential role as a catalyzer in the dark phase of photosynthesis. III, 153; V, 52; VI, 15.

Vitelline membrane: a delicate non-cellular membrane surrounding the egg. It is probably secreted by the ovum itself inside its follicle in the ovary. I, 128.

Vitellus: see Yolk.

Volvox: a flagellate protozoa. According to the species of *Volvox*, 500 to 20,000 individuals are grouped in a gelatinous sphere that moves by means of flagella. III, 57; mi.

Vomeronasal: an accessory organ of olfaction found in numerous vertebrates. II, 74.

W

Warburg's apparatus: an apparatus that measures the minute gaseous exchanges of cell respiration. IV, 49.

Went's test: a method used in plant physiology that enables us to detect and measure the concentration of growth substances in coleoptiles. If a cube of gel is placed on a growing stem which has been previously in contact with a coleoptile, and in which the growth substance has diffused, this stem grows faster on the side on which the cube is placed. The bend thus produced is proportional to the quantity of substance diffused; from this, therefore, arises the possibility of carrying out quantitative measurements. III, 83.

White blood cell (or leucocyte): a cellular element of the blood with the property of movement and able to put out pseudopods and ingest any foreign particles in the blood. Leucocytes are mononuclear or polymorphonuclear, formed either in the lymph nodes, or in the bone marrow, and play a part in the defence of the organism: they destroy microbes by phagocytosis. At the points of microbial invasion, leucocytes congregate and may die in large quantities, thereby constituting pus. Certain white cells, the lymphocytes, secrete antibodies; these cell elements also produce certain coagulation factors in the blood. I, 66, 67; IV, 112-114, 123; V, 30, 31; VI, 131, 132, 134, 135; VII, 34, 35, 53, 98.

Whitlow: acute inflammations of the fingers, whatever their nature, extent and depth. Such disorders must be detected and treated early; certain deep attacks, in tendon and bone, and their possible extension to the hand may lead to permanent functional sequelae which may be of a grave nature; hence the danger of attacks on the right thumb. VI, 15, 23.

Whooping cough: a disease caused by the Bordet-Gengou bacillus, characterized by attacks of spasmodic cough, interrupted by a long and whistling inspiration after each cough. IV, 131; VI, 51; VII, 81.

Wolffian ducts: one of the two sets of urinogenital ducts in vertebrate embryos. In the male it is the origin of the epididymis, of the vas deferens, and of the seminal vesicle. It disappears in the female of higher vertebrates. I, 144-150.

X

X-rays: radiations of the same nature as light, but of much smaller wave-length. X-rays affect photographic plates in the same way as light. The absorption of x-rays depends on the density and atomic weight of the substance through which they pass. Thus bones are more opaque than flesh surrounding them; this makes it possible to radiograph the human body. III, 133; VI, 134; VII, 11.

Xenogamy: a mode of fertilization in which pollen and ovules are produced by different individuals (cross-fertilization). IV, 127, 130.

Y

Yarovization: see Vernalization. III, 106.

Yaws: an infectious disease characterized by the appearance on the skin of swellings, or yaws, with a granular surface resembling raspberries. The disease is produced by a spiral-shaped bacterium, the *Treponema pertenue*, an organism closely related to the *Treponema* of syphillis. VII, 141.

Yeast: a unicellular fungus of the class Ascomycetes. One species of yeast is responsible for the fermentation of alcohol; another, a pathogen, is *Candida albicans*, a cause in man of the disease called thrush. The beer yeast, *Saccharomyces*, is used in the industrial manufacture of vitamins of the B group. IV, 144, 146; V, 52.

Yellow fever: an infectious disease caused by a virus and transmitted by a mosquito, *Aedes aegypti* (sometimes called *Stegomya fasciata*) for urban epidemic yellow fever, and for scrub endemic yellow fever perhaps a mosquito of the *Haemagogus* genus. It begins suddenly with a high fever (40°C) and violent pains in the head and lumbar region, vomiting, and facial congestion. In its benign forms, the fever falls in three or four days and recovery takes place. In the serious forms, the fever recurs with vomiting of blood, jaundice and albuminura; the disease is then fatal. It is caused by a filtrable virus. This disease may be prevented by vaccination with attenuated viruses, these having been attenuated by successive passages on white-mice brains, used alone or with yolk of egg, or enveloped in the serum of an animal that has had yellow fever. VI, 19, 22, 23.

Yolk: a reserve substance contained in the eggs of certain animals. Yolk is composed of albumen and fats. Depending on the quantity and distribution of yolk (none, little, or much) eggs are classified as lecithical, oligolethical or telolethical. I, 128, 130.

Z

Ziehl method: a method of staining which allows observation of the tubercle bacillus, alcohol, and acid-resistant bacilli IV, 52; VII, 38.

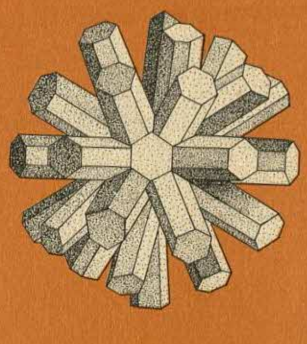
Zone of Golgi: see Golgi.

Zoospore: a spore that moves by means of cilia or flagella. III, 68.

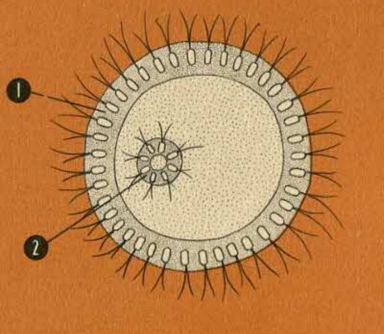
Zygomeiosis: in lower plants, meiosis immediately following the formation of the egg. III, 57.

Zygote: a product of the union of a male gamete with a female gamete. The fertilized egg is a zygote. I, 119, 123, 124.

Zygotene (or synapsis): a stage of meiosis (prophase) during which the two chromosomes of one pair come closely together. It is during this stage that crossing-over or gene exchange occurs, a phenomenon of great importance in the modalities of transmission of hereditary characters. I, 118.



Virus, polyoma
This virus is responsible for several cancers in the mouse. It is in the form of about forty prisms. positioned in the shape of a symmetrical icosahedron.



Volvox
1. Mother colony. 2. Daughter colony.

Important dates in biology and medicine

An asterisk indicates that the term referred to is defined in the Glossary.

Physiology

1628 William Harvey discovered the circulation of the blood.

1664 Regnier de Graaf collected pancreatic juice.

1759–1766 Albrecht von Haller published his *Elementa Physiologiae.*

1791 A. L. Galvani obtained muscular contraction by electrical stimulation.

1824 W. Prout found hydrochloric acid in gastric juice.

1826 Johannes Müller enunciated the law of specific nerve energies.

1847 H. von Helmholtz measured the rate of transmission of nerve impulses.

1878 Claude Bernard demonstrated the importance of the constancy of the internal environment.

1897–1922 I. P. Pavlov's work on the conditioned reflex.

1902 W. M. Bayliss and E. H. Starling discovered the hormone secretin.

1906 C. S. Sherrington demonstrated the integrative functions of the nervous system.

1906 F. G. Hopkins proved the importance of accessory food factors, i.e., vitamins.

1914 H. H. Dale demonstrated the parasympathomimetic function of acetyl choline.

1923 F. G. Banting and C. H. Best extracted insulin from the pancreas and cured diabetes.

1929 A. V. Hill and W. Hartree analysed the heat-production of muscle.

1929 Johannes Berger demonstrated that electrical activity of the brain could be recorded.

1934 E. D. Adrian and B. H. C. Matthews confirmed Johannes Berger's findings.

The cell

1665 Robert Hooke, examining sections of cork under a lens, observed the alveoli, to which he gave the name of 'cells'.*

1676 Antoni van Leeuwenhoek studied and described human blood corpuscles,* spermatozoa* and infusoria.*

1682 Nehemiah Grew and Marcello Malpighi confirmed the existence of cells or 'vesicles' in different plants.

1777 Lazzaro Spallanzani differentiated white* from red corpuscles.

1781 Gregorio Fontana observed the nucleus for the first time; this was described more completely by C. F. B. de Mirbel in 1800.

1824 Henri Dutrochet stated that cells are the units of which living beings are built.

1831 Robert Brown correctly described the nucleus and confirmed that it is always present in cells.

1837 F. Raspail published his *Système de Physiologie Végétale* and stated the principles of the organization of plants (potentiality, cell differentiation, and endogenous and exogenous reproduction).

1838 The nucleolus, observed by G. Fontana, was studied by M. J. Schleiden and T. Schwann.

1839 M. J. Schleiden announced the cellular theory of plants, and T. Schwann extended this theory to the animal kingdom.

1840 Jan Purkinje and Hugo von Mohl gave the name protoplasm to the gelatinous substance, already recognized by Félix Dujardin in 1835, that makes up the cell.

1846 Karl von Naegeli demonstrated that new cells are formed from old ones.

1861 Max Schultze gave a definition of the cell: a small mass of protoplasm containing a nucleus.

1875 Oskar Hertwig observed the fertilization of a single egg nucleus by a single sperm nucleus. The cell membrane was described and studied by Louis Ranvier.

1879–1882 W. Schleicher observed the phenomenon of indirect division which he called karyokinesis, and in 1880 W. Flemming discovered the splitting of chromosomes. In 1882, he called it mitosis* and studied its mechanism. Flemming also described meiosis.*

1882–1910 C. Benda, W. Flemming and R. Altmann described mitochondria.* Further study of the chondriome* was carried out in 1910 by A. Guillermond and P. A. Dangeard.

1892 According to Oskar Hertwig, the solution of biological problems was to be found in cellular processes.

1899 Camillo Golgi observed the cytoplasmic bodies known as the Golgi* zone.

1920–1940 R. Feulgen developed staining techniques that can show the presence of deoxyribonucleic acid in the cell nucleus. In 1940, Jean Brachet demonstrated ribonucleic acid. With T. Caspersson, he propounded the hypothesis of the role of nucleic acids in the synthesis of proteins.*

1945 Study of living cells with the phase-contrast microscope.

1950 Beginning of the discoveries of the ultrastructure of cytoplasm (microsomes*) by means of the electron microscope.

The embryo

17th Century. With the use of the microscope came the beginning of embryology. The year 1621 saw the posthumous publication of Fabricio de Aquapendente's, *The formation of the hen's egg and the development of the chick;* works by William Harvey *(On the Development of Animals),* by Marcello Malpighi on the hen's egg, Regnier De Graaf on the development of mammals, and by A. van Leeuwenhoek. Two contrary theories were propounded: the theory of preformation (development is only the enlargement of preformed parts in a germ) and the theory of epigenesis (the structure of organs is only formed progressively, creation of differentiation afresh in each generation).

1759 Caspar Friedrich Wolff confirmed the theory of epigenesis.

1825 Karl Ernst von Baer studied and described the mammalian follicle. He formulated two fundamental principles of embryology: (a) the theory of germ layers; (b) the importance of the spinal cord in the embryogenesis of vertebrates.

19th Century. The development of comparative embryology (Robert Remak, Heinrich Rathke and Ernst Haeckel. First attempts at experimental teratology by Etienne Geoffroy-Saint-Hilaire (1826), followed by C. Dareste (1874).

1885 Wilhelm Roux founded the science of experimental embryology.

1900 Artificial parthenogenesis of the sea-urchin (Jacques Loeb).

1910 Hans Spemann's experiments on the differentiation of the lens introduced the theory of induction. First experiments on parthenogenesis in the frog (Eugène Bataillon).

1916 Frank R. Lillie described free-martin embryos.

1923 W. Vogt applied the technique of colour markings on living embryos to determine the prospective fate of different parts.

1930–1935 Experimental embryology of the sea-urchin by Sven Hörstadius; of Amphibia by Otto Mangold and Paul Wintrebert; and of *Amphioxus* by Edwin G. Conklin. Hans Spemann, Albert Dalcq, Jean Pasteels, Jean Brachet, Joseph Needham and C. H. Waddington attempted to ascertain the chemical nature of induction.

1938 Work by G. Pincus on experimental parthenogenesis in mammals, continued by Thibault (1950–1962).

From 1940. H. H. Chuang and Sulo Toivonen made investigations into the nature of the inductor. Etienne Wolff worked on experimental teratology. J. Benoit, A. Jost and A. Raynaud studied the development and differentiation of genital organs and endocrine glands in vertebrates. In 1961, H. Holtzer, in Philadelphia, isolated an inductor substance.

Nucleic acids

1868 Discovery of nucleoproteins by F. Miescher.

1870–1889 A. P. Matthews, H. Plosz, P. Ackerman and L. Lilienfeld isolated the nucleoproteins of numerous animal and plant substrates. Richard Altmann obtained purified preparations of nucleic acids (1889).

1920–1928 Biochemical study and classification of nucleic acids of varying origin by A. Kossel and his pupils. Distinction between thymonucleic (now known as deoxyribonucleic) and ribonucleic acid; work of Steudel, Jones and P. A. Levene.

1935 W. M. Stanley first crystallized the tobacco mosaic virus and, with F. C. Bawden, showed that certain viruses may be constituted solely of nucleoproteins. Cytochemical study of nucleic acids by means of Feulgen's staining technique (1928–1930) and also that of Jean Brachet.

1937–1946 Histochemical and cytochemical work by the school of T. Caspersson in Sweden, and Jean Brachet in Belgium, showed the localization of nucleic acids in the cell. Caspersson's hypothesis on the role of nucleic acids in the synthesis of proteins. G. Claude, in 1941, isolated and purified RNA by ultracentrifugation.

1944 DNA identified as the vector of hereditary character (O. T. Avery).

1946 J. N. Davidson and his pupils determined more precisely the biochemical nature of nucleic acids.

1946–1954 Chemical composition and structure of nucleic acids revealed by E. Chargaff and by Lord Todd and D. M. Brown; study of nucleic acids by x-ray crystallography by M. H. F. Wilkins; J. D. Watson and F. H. C. Crick, in 1954, showed that DNA possesses a double helical structure.

1957–1960 Numerous publications (W. M. Stanley, M. Chase, A. D. Hershey, A. Boivin and R. Vendrely) on the nucleic acids of bacteria and viruses. Work leading to the discovery of the genetic code. Research on specific enzymes.

1961 Observation of messenger RNA, which transports, from the nucleus to the cytoplasmic centre of protein synthesis, the genetic information preserved from one generation to another by DNA. H. Hyden's hypothesis, according to which RNA is the material basis of memory.

1962 F. H. C. Crick and J. D. Watson put forward a solution of the genetic code.

Bacteria and viruses

1861 In a series of communications to the French Academy of Sciences and the Academy of Medicine, Louis Pasteur showed the part played by germs in the suppurations of wounds and layed down the principles of sterilization (asepsis and antisepsis). G. H. A. Hansen described the leprosy bacillus.

1876 Robert Koch extended the work of Casimir Davaine (1863) and discovered the anthrax spore.

1878 On April 30, Pasteur, in collaboration with Charles Chamberland and J. Joubert, delivered his famous paper on the theory of germs. Charles Sedillot invented the word 'microbe' and used it in a communication to the Academy of Medicine, 'On the influence of the work of M. Pasteur on the progress of medicine.'

1880–1900 Discovery of the main pathogenic bacteria:* diphtheria,* typhoid,* tetanus,* etc.

1881 Robert Koch described the technique of solid medium culture, permitting easy separation of germs.

1882 Robert Koch discovered the tuberculosis* bacillus.*

1888 Emile Roux and Alexandre Yersin discovered the existence of soluble bacterial toxins (diphtheria toxin).

1890 Knud Faber and S. Kitasato discovered tetanus toxin.

1894 Discovery of the plague bacillus by Alexandre Yersin.

1898 The concept of 'filtrable virus' was suggested by Friedrich Loeffler and P. Frosch for foot-and-mouth disease.

1910 Charles Nicolle and E. Conseil showed that the flea is the usual vector of typhus.

1916–1918 Research by F. W. Twort and F. D. Hérelle on the bacteriophage.*

1930–1952 Work on bacterial genetics. Following the experiments of F. Griffith (1928), transformation was described and studied by J. L. Alloway (1932), and André Boivin (1947), and recombination by E. L. Tatum and G. W. Beadle (1946). In 1952, N. D. Zinder and Joshua Lederberg described transduction in lysogen bacteria. Work by A. Lwoff, J. Monod and others.

1935 W. M. Stanley obtained tobacco mosaic virus in crystalline form.

1935 onwards. The ultracentrifugation and ultrafiltration techniques led to more precise knowledge on the size of viruses. These can now be seen under the electron microscope.

1950 onwards. Demonstration of bacterial sexuality (F. Jacob and J. Wollman). Work on structure, chemical composition, antigen potency and mode of reproduction of viruses.

1957–1965 Research on interferon.

Blood groups

1896–1898 Jules Bordet described the agglutination phenomenon of the cholera vibrio and of red cells in various animals.

1899–1901 K. Landsteiner showed that isoagglutination is a biological phenomenon which allows human beings to be classified into different groups.

1903 K. Landsteiner and M. Richter suggested a method of showing in certain cases whether a spot of blood could not have come from a given individual.

1909–1910 E. von Dungern and L. Hirszfeld showed the hereditary links between blood groups of parents and children: O, A, B and AB agglutinogens are transmitted according to Mendel's laws.

1911 L. Hirszfeld distinguished groups A_1, A_2, A_1B and A_2B.

1925–1940 K. Landsteiner and P. A. Levine discovered the characters M, N, and P, also transmitted according to Mendel's laws.

1926–1927 L. Lattes, and later F. Schiff, discovered new techniques leading to medico-legal applications of the properties of blood groups.

1931 F. J. Holzer identified A and B agglutinogens in blood by means of absorption of O group test-sera. P. Dahr, in 1943, proposed using isolated anti-A and anti-B test sera. L. Hirszfeld and R. Amzel discovered substances with the properties of blood groups; these substances derive from organic secretions.

1939–1940 The Rhesus factor first detected by K. Landsteiner and A. S. Wiener.

1941 P. Levine, E. M. Katzin and L. Burnham showed that Rhesus groups can produce haemolytic disease of the newborn.

1941 to date. All the sub-groups of the Rhesus system were discovered, as well as those of other systems: Kell-Cellano, Kidd, Lutheran, Lewis, Duffy, etc. Each year, new blood group factors are discovered.

1954 A. E. Mourant systematized knowledge of blood-groups.

Experimental cancer

1889–1894 A. N. Hanau and H. Morau were the first to graft cancer tumours* in animals (mice).

1900 Grafted cancer* becomes a developed technique (the work of L. Loeb, C. D. Jensen, P. Ehrlich, A. Borrel and M. Haaland).

1901 'Parasite' phase. M. Askanazy published the first observation of human cancer caused by a parasite* (liver fluke*). Soon after, A. Borrel discovered that the liver sarcoma* of the rat may be due to *Taenia crassicolis*. Later, J. Fibiger described the carcinogenic activity of a nematode* (*Spiroptera neoplastica)* in the rat.

1903 A. Borrel put forward the hypothesis that cancer is caused by a virus (studies of diseases with marked cellular proliferation: verrucae, sheep-pox and small-pox).

1908 Avian leukaemia discovered by B. L. F. Bang and V. Ellerman.

1910 Radiation cancer. P. Marie, J. Clunet and G. Raulot-Lapointe induced cancers in animals by means of x-rays: the first cancers induced at will. Experimental transmission of cancer by filtrate (research by Peyton Rous on chicken sarcoma), the same results were obtained in the same year by two Japanese research workers, A. Fujinami and K. Inamoto.

1914 'Hereditary' phase. The beginning of research by Maud Slye on the possible hereditary* nature of cancer. Isolation of pure strains of cancerous and non-cancerous mice.

1917–1920 'Chemical' phase. Carcinogenetic action of tar in the rabbit (K. Yamagiwa and K. Itchikawa) and in the mouse (H. Tsutsui).

1920–1930 'Hormone'* phase. In 1910, L. Loeb observed that removal of ovaries prevented the appearance of a cancer in cancer strains of mice. Antoine Lacassagne showed, some years later, the importance of steroid hormones in the genesis of some cancers in mice. Confirmation of these results in rat cancers (H. Burrows), W. U. Gardner, G. M. Smith, E. Allen and L. C. Strong, C. F. Geschickter).

1930–1940 'Virus' phase. C. Oberling and M. Guérin showed (1933) that it is possible to modify the exclusive cytotropism of the avian leukaemia virus for the immature white cells. This virus can cause connective tissue cancers (Peyton Rous).

1932–1934 Research by Peyton Rous and F. D. Reynals on avian leukaemia, induced in the duck, turkey, etc.

1933–1935 Work of R. E. Shope on rabbit papilloma.*

1936 Discovery of J. J. Bittner's lactate factor, a virus causing mammary cancer in mice.

1940–1965 Discovery of new cancer-producing chemicals. From 1947, a number of cancer viruses were photographed with the electron microscope. The search for leukaemia viruses continued: this led to the discovery of the polyoma virus (1957, S. E. Stewart). Work of A. and B. Pulmann on the electronic structure of tars. Development and clinical trials of a number of chemical substances for the treatment of cancer (antimitotics, antimetabolites, cytotoxic agents). Reports by medical bodies on the correlation between cigarette smoking and lung cancer.

Anaesthesia

1772 Joseph Priestley discovered nitrous oxide (laughing gas).

1802 Frederick Sertuerner discovered morphine.

1842 Crawford Williamson Long used ether for inhalation.

1844 Horace Wells used laughing gas for dental operations.

1846 C. T. Jackson, a chemist, and William Morton, a dentist, anaesthetized a patient with ether.

1847 Sir James Young Simpson made a patient unconscious with chloroform.

1885 Production of local anaesthesia with cocaine.

1894 Anton Carlson discovered the anaesthetizing properties of ethyl chloride.

1898 August Bier became the first to adopt spinal anaesthesia.

1905 Alfred Einhorn and H. F. W. Braun discovered procaine.

1917 Rectal anaesthesia carried out in Germany.

1929 Induction of anaesthia in man by intravenous injection of sodium-iso-amyl-ethyl-barbiturate.

1930 R. M. Waters administered cyclopropane.

1935 Clinical experiences by C. Striker *et al* with the use of trichlorethylene in the production of over 300 analgesias and anaesthesias.

1942 Introduction of curare in anaesthesia by H. R. Griffith and G. E. Johnson.

1950 H. Laborit in France and H. Bigelow in Canada described induced hypothermia (hibernation).

S.C.E.R.T., West Bengal
Library

Surgery

5th Century B.C. Hippocrates wrote the first treatise on surgery.

1363 G. de Chauliac (Montpellier) wrote *Chirugia Magna*, printed in French, in 1478.

1540 The Surgeons of London incorporated.

1550 Pierre Franco invented hypogastric section and the treatment of hernia.

1552 Ambroise Paré and others performed the first amputations and vessel ligatures.

1639 John Woodall published *The Surgeon's Mate*, the first book on military surgery.

1731 Foundation of the Royal Academy of Surgery in Paris.

1775 John Hunter introduced experimental surgery.

1800 Dominique Larrey recommended rapid amputation after deep wounding, in order to avoid infection.

1809 Ephraim McDowell performed an ovariotomy.

1840 First hysterectomies carried out by Bernhard Rudolf Langenbeck.

1858–1860 Spencer Wells carried out ovariotomies (on patients with cysts*).

1861 Louis Pasteur published his paper on germs in the atmosphere.

1865 Joseph Lister introduced the technique of antisepsis in surgical operations.

1872 In the United States, Robert Battey perfected the ovariotomy technique and the operation for uterine fibromas.

1884 A. H. Bennett and R. J. Godlee diagnosed, localized and removed a brain tumour.

1888 Removal of a brain tumour by Sir Victor Horsley.

1914–1918 Formation of surgical teams and prevention of post-operative shock.

1920–1940 Improvement of techniques and surgical materials.

1923–25 E. C. Cutler and S. A. Levine in America and Sir Henry Souttar in Britain successfully operated for mitral stenosis.

1935–1955 Development of brain surgery (leucotomy* and lobotomy). The work of Wilder Penfield and René Leriche.

1945 Surgical repair of malformations of the heart by Alfred Blalock at Baltimore, and in 1948 by Sir Russell Brock in London.

1950 to date. First open-heart operations; aorta operations. Improvement of neurosurgery. Renal transplant operations.

Medicine and methods of treatment

1673 The use of inoculation for smallpox in Constantinople.

1718–1721 Lady Mary Wortley Montagu, wife of the English ambassador at Constantinople, had her children inoculated with smallpox and introduced the method into England.

1796 On May 14, Edward Jenner carried out a vaccinial inoculation. Having taken the virus from a pustule on a dairymaid's hand, who had been infected by contact with her animals, he put it into the arm of a boy aged eight, James Phipps. The inoculation was successful: the boy was 'vaccinated' against smallpox.

1816 R. Laënnec invented the stethoscope.

1880 Louis Pasteur studied chicken cholera. He discovered the phenomenon known as 'virus attenuation'.

1881 In May, experiment by Pasteur at Pouilly-le-Fort on anthrax vaccination.*

1885 First vaccinations of man against rabies performed on Joseph Meister and J. B. Jupille.

1890 Charles Richet announced the principle of serotherapy.* Robert Koch announced the discovery of a specific remedy (tuberculin) against tuberculosis. E. von Behring and S. Kitasato showed that an animal immunized with diphtheria toxin acquires antitoxic properties in its serum.

1894 Emile Roux published the first statistics of the treatment of diphtheria by serotherapy.

1895–1900 Development of numerous sera; these were used with varying success.

1899 Almroth Wright, after G. Widal and A. Chantemesse and before H. Vincent, actively defended the efficacy of typhoid vaccine.

1900–1918 Development of numerous vaccines, such as typhoid and paratyphoid vaccine.

1923 A. T. Glenny, K. Allen and B. E. Hopkins published their paper on the antigenic value of diphtheria toxin-antitoxin mixtures for human immunization.

1926–30 A. T. Glenny summarized the use of toxoids for immunization.

1928 Discovery by Alexander Fleming of the bactericidal action of the mould *Penicillium notatum*.

1930-1935 Discovery of the protective action of sulphonamides* (F. Mietzch and J. Klarer, G. Domagk and others).

1939 Howard Florey and Ernst Chain and others, produced a stable form of penicillin.

1937–1950 Discovery of a number of antihistamines by B. Halpern.

1941 First treatment of man with penicillin; recovery of six cases of septicaemia.* Beginning of the antibiotics* era.

1944 Discovery by S. Waksman of streptomycin.

1945–1956 Discovery of chloromycetin, tetracyclines and synthetic penicillins. Development of vaccines against virus diseases (poliomyelitis and measles).

1948 Discovery of para-amino-salycylic acid (PAS).

1950–51 Observation of anti-inflammatory action of cortisone. Discovery of isoniazid (INH).

1955–1962 Discovery of new anti-inflammatory principles (enzymes).

STATE INSTITUTE OF EDUCATION

Printed in Italy by Officina Grafica Mondadori, Verona—Filmset on the 'Monophoto' by Photoprint Plates Ltd., Wickford, England.

THE LIVING UNIVERSE

An Encyclopaedia of the Biological Sciences

The living organism
Life at the molecular level—From cell to organised being—Possibilities and limitations of the living being—The development of the embryo.

The animal world
The singular nature of our kingdom—Animal groups—Sexuality—Animal thought.

The world of plants
How plants colonised the mineral world.

The world of microbes
Bacteria and viruses—Is aseptic life possible?

The human machine: I. the mechanisms
The important inner links—The nervous system—The neuro-physiological bases of mind.

The human machine: II. disorders
The major bacterial diseases—Allergies—Cancer and leukemia.

The human machine: III. adjustments
Deciphering the disorders—The treatment of disease—Pharmacology.

Man of tomorrow
Improving the environment—Improving the species—Grafts and eugenics—Man of the future—Medicine of the future.

NELSON
36 PARK STREET, LONDON W.1